Proposed Revisions of PSD Permit Number PSD-X82-01 For Sources to be Added to the Kuparuk River Unit, Kuparuk, Alaska

Prepared for:

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RADIAN
CORPORATION

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DCN 82-121-241-04

PROPOSED REVISIONS OF PSD PERMIT NUMBER PSD-X82-01 FOR SOURCES TO BE ADDED TO THE KUPARUK RIVER UNIT, KUPARUK, ALASKA

Submitted by:
Arco Alaska, Inc.

Submitted to:
U. S. Environmental Protection Agency Region X
and
State of Alaska
Department of Environmental Conservation

Prepared by:
Radian Corporation

2 December 1982

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EXECUTIVE SUMMARY

In April 1981, Arco Alaska, Incorporated (Arco) submitted a permit application to the United States Environmental Protection Agency (USEPA) Region X to construct facilities at the Kuparuk, Alaska Oil Field in accordance with the requirement of USEPA's Prevention of Significant Deterioration (PSD) regulations which were promulgated August 7, 1980. The timing for submission of the permit application was dictated, in part, by Arco's production schedule, which required an expeditious start on construction of the facilities.

In order to prepare the PSD permit application for a timely review by USEPA Region X, the facilities design had to be based on preliminary information, which constituted the best information available at that time. Since submittal of the original application an updated facilities design has become available.

This document describes the revisions requested for PSD Permit No. PSD-X82-01, incorporating all design changes currently anticipated to occur through construction of these facilities. Under the PSD regulations, the modified Kuparuk River Unit facilities will continue to be a major source of emissions of nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter (PM), volatile organic compounds (VOC), and carbon monoxide (CO).

Because there was a possibility that a refined engineering analysis might result in a number of facility design changes, the analysis for the originally proposed facilities was conservative in identifying air quality impacts. Emissions estimates resulting from the revised facilities design are equal or less than overall emissions for all the pollutants addressed in the original permit application.

Air quality impacts associated with the modified facilities do not differ significantly from the impacts presented in the original permit application. Operation of the facilities as proposed in this revised permit application is not predicted to cause or contribute to air pollution in violation of any national ambient air quality standard or any PSD increment. Estimated emission levels for each of the pollutants based on the revised design are less than the levels identified in the original application, and Best Available Control Technology (BACT) is applied for the pollutants as discussed in the original application. In addition, it is not anticipated that the modified facilities will result in any change to the analyses already conducted for impacts of induced growth, soils, vegetation, or visibility.

1.0 INTRODUCTION

This revised permit application addresses impacts associated with design changes for the Kuparuk River Unit facilities. The overall concept of the Kuparuk River Unit facilities is unchanged from that presented in the original permit application. The Kuparuk River Unit facilities will still consist of drill sites, water injection facilities, additional power production facilities, a combined waste incinerator, and expansion of the existing Central Production Facility (CPF-1). Existing and previously licensed sources at CPF-1 will not change from the description in the original permit application.

Gas turbines and heaters still constitute the majority of the pollutant-emitting sources. A more detailed discussion of emissions sources, proposed emission controls, and air quality impacts of the modified Kuparuk River Unit sources is contained in the remainder of this report.

1.1 Proposed Changes

The current Kuparuk River Unit facilities design does not change the basic character of the Kuparuk River Unit production plan. Gas-fired heaters and turbines will continue to be the primary sources of atmospheric emissions, although there are differences in the numbers of various units and the distribution of the production facilities in the oil field. Table 1-1 presents a comparison of the total emissions as currently proposed and as originally permitted and demonstrates that the currently proposed emissions are lower for each pollutant. Table 1-2 shows the currently proposed emissions distribution by source type.

TABLE 1-1

POTENTIAL EMISSIONS FROM THE PROPOSED FACILITY

(TONS/YR)

Pollutant	Permitted	Currently Proposed
NO_x	15,226	14,122
SO_2	86	85
PM	380	344
VOC	53	51
CO	2,964	2,789

TABLE 1-2

CURRENTLY PROPOSED EMISSIONS DISTRIBUTION BY SOURCE TYPE

(TONS/YR)

Source Type	NO_x	SO_2	PM	VOC	CO
Turbines	13,730	72	293	50	2730
Heaters	384	9	39	0.5	42
Incinerator	8	4	12	0.5	17
TOTAL	14,122	85	344	51	2789

The regional location of the Kuparuk River Unit will not change; however, changes in the number and location of the individual production facilities within the oil field will occur. The location of the Kuparuk River Unit is shown in Figure 1-1.

The new oil field development plan calls for three production facilities. The new production facilities will be named Central Production Facility-1 (CPF-1), Central Production Facility-2 (CPF-2), and Central Production Facility-3 (CPF-3). The three corresponding originally permitted facilities were named the Central Production Facility, the South Production Facility, and the West Production Facility. Sources originally permitted for the North Production Facility will be distributed to other facilities described in this document or deleted from the revised source list.

Six 4.9 MHP turbines originally permitted at the North Production Facility will be moved to CPF-1 and permitted as 5 MHP turbines. One 14 MHP turbine originally permitted at the North Production Facility will be moved to CPF-3. The remaining originally permitted North Production Facility sources will be deleted. Changes to the originally permitted source mix at both the new CPF-2 and CPF-3 facilities will include the addition of two 5 MHP turbines and the deletion of seven 10 MMBtu/hr heaters. A comparison of the new locations of the facilities in the oil field to the previously permitted locations is shown in Figure 1-2.

Gas Turbines

The total number of turbines proposed for the Kuparuk River Unit expansion will be reduced from 47 to 46. The turbines range in capacity from 5 MHP to 34 MHP with a total rating of 570 MHP. The total originally permitted turbine capacity was 599.6 MHP. The revised turbine equipment list is shown in Table 1-3.

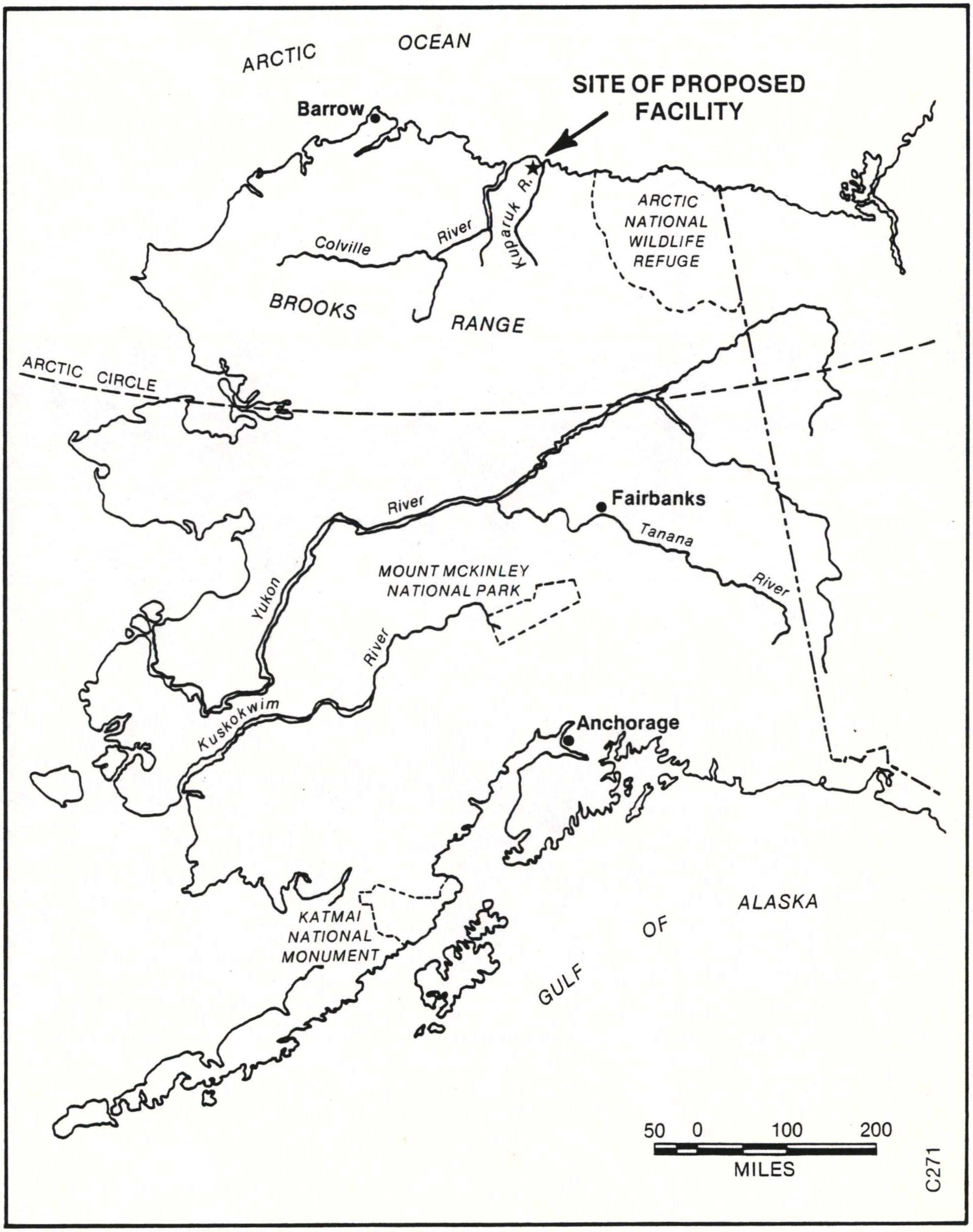

Figure 1-1. Location of the Kuparuk Area

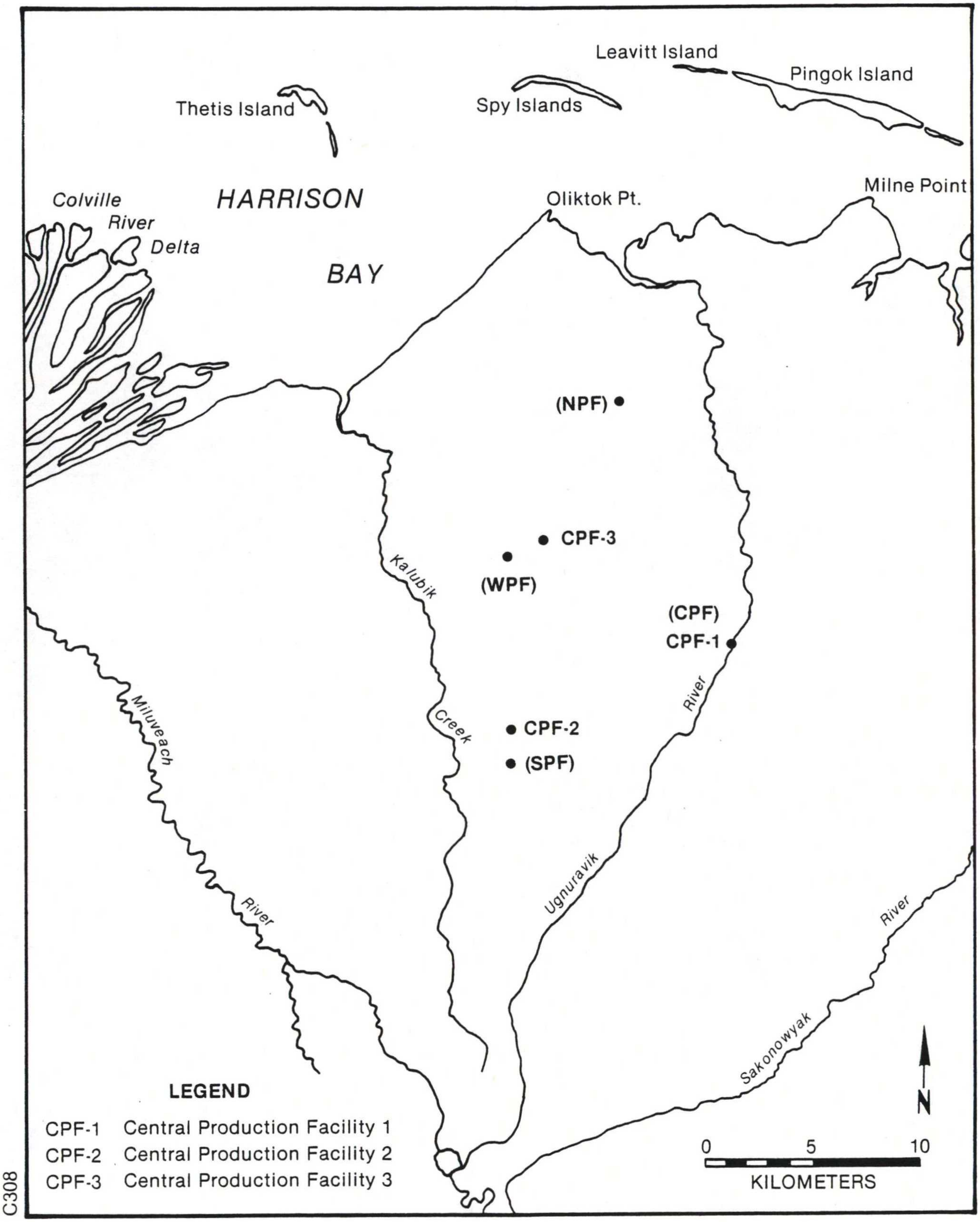

Figure 1-2. Comparison of the Revised and Previously Permitted Facilities Locations

TABLE 1-3

KUPARUK RIVER UNIT SOURCES

Previously Permitted Facilities Source List

Location	Number of Units	Description
Central	3	14 MHP Turbines
Production	8	34 MHP Turbines
Facility	21	10 MMBtu/hr Heaters*
	1	Crude Oil Topping (COT) Unit Flare
	1	40 MMBtu/hr COT Heater
South	8	4.9 MHP Turbines
Production	4	14 MHP Turbines
Facility	25	10 MMBtu/hr Heaters*
		20 MMBtu/hr Heater
West Production	8	4.9 MHP Turbines
Production	4	14 MHP Turbines
Facility	25	10 MMBtu/hr Heaters*
	1	20 MMBtu/hr Heater
North	8	4.9 MHP Turbines
Production	4	14 MHP Turbines
Facility	25	10 MMBtu/hr Heaters*
	1	20 MMBtu/hr Heater

Revised Facilities Source List

Location	Number of Units	Description
Central	6	5 MHP Turbines
Production	3	14 MHP Turbines
Facility-1	8	34 MHP Turbines
	21	10 MMBtu/hr Heaters*
	1	765 lb/hr Incinerator
	1	40 MMBtu/hr Heater
Central	10	5 MHP Turbines
Production	4	14 MHP Turbines
Facility-2	18	10 MMBtu/hr Heaters*
	1	20 MMBtu/hr Heater
Central	10	5 MHP Turbines
Production	5	14 MHP Turbines
Facility-3	18	10 MMBtu/hr Heaters*
	1	20 MMBtu/hr Heater

*The 10 MMBtu/hr heaters are assigned to the production facilities for dispersion modeling purposes. In actuality, they will be constructed at sites throughout the Kuparuk Oil Field.

Turbine emission rates and stack parameters are listed in Table A-9 of Appendix A. Sample emission calculations are shown in Appendix B. Emission rates are calculated using the same procedure described in the original application. All operating turbines will burn natural gas identical to the natural gas described in Table B-1 of the original permit application. For convenience, the natural gas composition is also shown in Appendix B of this document.

Heaters

A total of 60 space and process heaters will be installed in the Kuparuk River Unit as part of this revised permit application. Total revised heater capacity is 650 MMBtu/hr. One hundred heaters were originally permitted for a total heater capacity of 1060 MMBtu/hr. The natural gas composition is identical to that originally proposed and is shown in Appendix B.

Heater emission rates are presented in Table A-9 of Appendix A. Emission rates are calculated in a manner identical to that in the original permit application. Sample calculations appear in Appendix B.

Other Emission Sources

A Crude Oil Topping Unit flare proposed in the original permit application to burn hydrocarbon vapors is no longer included in the design.

A 765 lb/hr combined waste incinerator is proposed in the revised permit request. No incinerator was proposed in the original permit application. The incinerator will be located at CPF-1 to augment the waste disposal capacity provided by the existing 1300 lb/hr incinerator.

The incinerator emission rate is presented in Table A-9 of Appendix A. Sample calculations are shown in Appendix B.

1.2 Applicant Information

This revision of PSD Permit Number PSD-X82-01 is being submitted by ARCO Alaska, Inc. (a subsidiary of Atlantic Richfield Company), operator for the Kuparuk River Unit. Addresses and contacts are as follows:

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Location of Source

Kuparuk Oil Field
Kuparuk, Alaska

Approximate Center of Kuparuk Field:

Latitude: 70° 20' N
Longitude: 149° 47' W
UTM Coordinates: 401.0 km East, 7802.8 km North
UTM Zone: 6

2.0 EXISTING ENVIRONMENT

2.1 Existing Climate and Air Quality

The information presented in Sections 2.2 (Climate) and 2.4 (Existing Air Quality) of the original PSD permit application was reviewed to insure that the most appropriate data were used to investigate air quality impacts for the proposed changes to the Kuparuk River Unit.

The availability of additional climate or air quality data was investigated by contacting the Environmental Protection Agency Region X and the Alaska Department of Environmental Conservation (ADEC). No additional data other than the on-site data for 1979-1980 used in the original application are available.

Based on this review of available climate and air quality data, the 1979-1980 on-site data remain the most representative for the Kuparuk area, and no changes to the discussions of climate and air quality presented in the original PSD permit application are necessary.

There have been no changes in the methods used to prepare the monitored data for use in the dispersion modeling. A listing of the joint frequency distribution of wind speed, wind direction, and stability class used for the annual modeling is shown in Appendix E.

Background pollutant levels for use in determining total air quality impacts on NAAQS were estimated from the data collected during the Prudhoe Bay monitoring program. To eliminate the influence of existing Prudhoe Bay area sources on the monitors, only those periods during which the monitors were upwind of all Prudhoe Bay sources were selected for use in the background estimation. For each pollutant, the mean of all concentrations measured during the selected periods was chosen as the background applicable for all averaging times with the exception that it is unreasonable to expect the mean background monitored concentration to exceed the mean annual monitored concentration. It was assumed that measurements occurring during periods of east-northeast winds at Drill Site 9 and west-southwest winds at Well Pad A would be representative of background conditions in the Prudhoe Bay and Kuparuk areas.

There have been no changes to the estimated background and monitored pollutant levels from those presented in the original PSD permit application. The monitored and background levels used in the air quality impact analysis are shown in Table 2-1.

2.2 Existing and Permitted Sources and Emissions

The inventory of existing and permitted sources examined as part of the air quality analysis for the original permit application has been reviewed to insure quality and completeness. The modeled inventory for this revised analysis is shown in Tables A-1 through A-8.

The Alaska DEC and EPA Region X were contacted to determine whether any additional sources should be included in the analysis. No additional sources were identified.

Prudhoe Bay sources are approximately 36 kilometers from the Kuparuk sources, and their impact in the vicinity of the Kuparuk sources will be small. However, Prudhoe Bay sources are included to insure a complete inventory.

A listing of all modeled revised sources with their stack and emissions parameters is included in Table A-9.

TABLE 2-1

ESTIMATED BACKGROUND AND MONITORED POLLUTANT LEVELS

	Pollutant Concentrations ($\mu g/m^3$)				
	NO_2	TSP	SO_2	CO	O_3
Annual Monitored Values					
For Source Segregation					
WSW Winds-Well Pad A	1	15	[1]	100	51
ENE Winds-Drill Site 9	2	5	[1]	190	51
Total Annual Mean					
Well Pad A	4	11	[1]	171	48
Drill Site 9	3.5	7	[1]	133	51
Estimated Background Levels[2]	2	11	<5[3]	171	51

[1] Below detection limit of instrument.

[2] Background levels estimated from measured data incidated by encircled values in table.

[3] Detection limit for continuous SO_2 analyzers operated in the Prudhoe Bay Air Quality Network.

3.0 BEST AVAILABLE CONTROL TECHNOLOGY (BACT)

Design refinements in the Kuparuk River Unit result in minimal changes to the emissions from the facilities. Since there have been no increases in the level of emissions, the types of emitting sources, or other factors which might affect the choice of emission control technology, the emission controls proposed in the original permit application still represent BACT. For comparison, both the total potential emissions for the original permit application and the revised total potential emissions are shown in Table 3-1.

In the interest of clarity, the emission controls proposed as BACT are repeated here. The discussion of alternative controls and justification of the proposed BACT can be found in the original permit application.

3.1 Proposed Controls Representing BACT

An analysis has been performed to determine BACT for the proposed facilities in a manner consistent with national and EPA Region X guidelines. The two major types of emitting sources are gas turbines and heaters. While these combustion sources emit significant amounts of particulate matter (PM), sulfur dioxide (SO_2), carbon monoxide (CO), and hydrocarbons (HC), the pollutants of greatest concern are the oxides of nitrogen (NO_x). BACT for gas turbines and heaters was determined according to the precedents set in the Unit Owner's PWI/LPS/AL and Waterflood permits (Permit Nos. PSD-X-80-09 and PSD-X-81-01). The controls proposed as BACT are summarized below:

TABLE 3-1

PROPOSED REVISED NET EMISSIONS INCREASES AND SIGNIFICANT LEVELS FOR KUPARUK RIVER UNIT SOURCES

Pollutant	Permitted Net Emissions Increase (t/y)	Revised Net Emissions Increase (t/y)	Significant Level (t/y)
CO	2,964	2,789	100
NO_x	15,226	14,122	40
SO_2	86	85	40
PM	380	344	25
VOC	53	51	40*

*VOC (Volatile organic compound) emissions were conservatively assumed to be 10 percent of total hydrocarbon emissions.

Turbines

NO_x emissions from the gas turbines are controlled by use of natural gas and dry controls incorporated into the combustion chamber design. This combination will meet the NSPS[1] limit of 150 x (14.4/Y) ppmv of NO_x in the exhaust and should be considered BACT. Other pollutants from the gas turbines are also limited by the choice of fuel (low sulfur, low ash).

Heaters

The NO_x emissions from heaters will be minimized by burning natural gas. This fuel choice also limits emissions of SO_2 and PM since natural gas contains very little sulfur and ash forming material. The emissions of all pollutants will be limited by periodic measurements of CO or O_2 in the flue gas to insure proper combustion conditions.

Other Facilities

In addition to the major emission sources (turbines and heaters), a multiple chamber refuse incinerator is included in the revised facility. The incinerator will combust about 765 pounds per hour of general refuse. The combination of adequate additional air and combustion temperature, a properly designed mixing chamber, and/or secondary burners will be used to minimize emissions. No additional controls are proposed as BACT for the incinerator.

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[1]New Source Performance Standard, Standards of Performance for Stationary Gas Turbines, Subpart GG, September 10, 1979.
Y = manufacturer's heat rate at manufacturer's rated load.

Besides the combustion-related emissions, there will be fugitive hydrocarbon emissions from process equipment. The process fugitive emissions will be minimized.

4.0 AIR QUALITY IMPACT ANALYSIS

4.1 Analysis Methodology

Atmospheric dispersion modeling techniques, recommended in the 1980 proposed EPA modeling guidelines were used to predict the total air quality impacts of the revised equipment in the Kuparuk River Unit. Annual modeling was performed using the Industrial Source Complex Long Term (ISCLT) model (Bowers, et al., 1979), and short-term modeling (24-hour averaging times or less) was performed using the Industrial Source Complex Short Term (ISCST) model. In the application of all these models the building wake effects option was used, and the rural mode of the model was chosen.

To facilitate a timely review of the revised permit application, the ISCLT and ISCST models were used, as required by EPA Region X. The appropriateness of the application of these models with the building wake effects option for modeling sources in the Kuparuk area has not been conclusively demonstrated.

For carbon monoxide, the proposed EPA short-term screening model, PTPLU, was applied. Resulting calculated ambient impacts were so low that more detailed modeling applications were considered to be unnecessary. Because of the low monitored concentrations of ozone in the area, and low sun angles, photochemical modeling of non-methane hydrocarbon emissions was considered to be inappropriate. Therefore, the potential impacts of hydrocarbon emissions on ozone levels were estimated through examination of Prudhoe Bay area monitoring results.

The ISCLT model was used to estimate annual average concentrations of NO, SO_2, and TSP due to the revised sources alone and in conjunction with existing and previously licensed sources. In the analysis, maximum NO_2 levels were predicted using the ozone limiting method described in the Proposed Revisions to EPA Guidelines on Air Quality Models, October 1980. Measured ozone concentrations and NO_x levels predicted by ISCLT were used in this analysis.

The ISCST model was used for calculations of 3-hour and 24-hour SO_2 concentrations and 24-hour TSP concentrations. Prudhoe Bay ambient air monitoring network data were used to estimate the contributions to total ambient short-term and long-term concentrations from background sources (Section 2.1). The impacts of all existing, previously permitted, and proposed sources in the Prudhoe Bay area were predicted with the dispersion models.

Meteorological data were obtained from the Prudhoe Bay area PSD monitoring network, as described in the original PSD permit application. These data are the most representative source of wind stability patterns in the Kuparuk area. The Kuparuk area Central Production Facility-1 is 36 km west-northwest of Prudhoe Bay Well Pad A. The two areas are similar in terrain, land use, and distance from the Beaufort Sea. Therefore, Prudhoe Bay air quality and meteorological monitoring data were used in describing baseline conditions and in modeling air quality impacts.

For annual modeling, a joint frequency distribution of wind speed, wind direction, and stability class for a one-year period (STAR deck) was used as meteorological input. The stability classes were calculated using the modified sigma theta method described in the 1980 EPA modeling guidelines. In the application of this method, based on discussions with EPA, Region X, stable conditions occurring at wind speeds greater than 11 knots were converted to stability Class D. For short-term modeling pre-processed hourly meteorological data from the Prudhoe Bay monitoring network were input to the ISCST model. Meteorological data processing is described in more detail in Appendix C. Dispersion model features are described in Appendix D.

4.2 Screening Analysis

4.2.1 Annual Screening

The revised emissions of NO_x, SO_2, and PM from the Kuparuk River Unit sources were modeled with the rural mode of ISCLT to determine the potential for significant impacts. The results are presented in Table 4-1.

The existing and previously licensed sources are located at CPF-1. The revised emissions sources in the Kuparuk River Unit are located at all three production facilities. The 60 proposed drill site heaters are distributed throughout the Kuparuk River Unit. For modeling purposes, 20 drill site heaters are assumed to be colocated at each of the three production facilities. The remaining pollutant sources are also assumed to be colocated at their respective facilities. Therefore, this modeling approach is conservative.

NO_x

Annual NO_x levels at receptors in the Kuparuk River Unit due to the Prudhoe Bay sources were predicted to exceed significant levels. Based on information obtained from the screening run, NO_x concentrations from the revised Kuparuk

TABLE 4-1

RESULTS OF SCREENING MODELING ANALYSES

FOR EMISSIONS FROM REVISED KUPARUK RIVER UNIT SOURCES

Pollutant	Averaging Time	Maximum Predicted Concentration ($\mu g/m^3$)	Significance Level[1] ($\mu g/m^3$)
NO_x	Annual	22.8	1
SO_2	Annual	0.4	1
	24-hour	5.2	5
	3-hour	9.4	25
TSP	Annual	1.6	1
	24-hour	20.6	5
CO	8-hour	<757[2]	500
	1-hour	757	2000

[1]As defined in 1977 Clean Air Act Amendments, Federal Register, June 19, 1978.

[2]The PTPLU model predicted a 1-hour average concentration of 757 $\mu g/m^3$. It is assumed that the 8-hour average concentration will be <757 $\mu g/m^3$.

River Unit sources were also predicted to exceed significant levels in the Kuparuk River Unit and at Prudhoe Bay. Therefore, ISCLT modeling runs were performed for all NO_x sources in the Prudhoe Bay and Kuparuk source inventories. From the screening run, five areas of maximum impact were identified for more refined NO_x modeling. These areas of maximum impact were located around CPF-1, CPF-2, and CPF-3 in the Kuparuk River Unit, and around Gathering Center 2 (GC-2) and Flow Station 1 (FS-1) in the Prudhoe Bay Unit.

$\underline{SO_2}$

Annual SO_2 concentrations due to emissions from the Prudhoe Bay sources did not exceed significance levels in the Kuparuk River Unit. Revised SO_2 emissions are greatest from CPF-1, therefore, based on information contained in the annual NO_x screening analysis, the maximum annual SO_2 concentration due to the Kuparuk River Unit sources should occur near CPF-1.

An 8x5 receptor grid with 0.25 km spacing was modeled only around CPF-1. Additional discrete receptors were placed 0.25 km west of CPF-2 and CPF-3 due to the higher frequency of westerly winds. Annual SO_2 concentrations due to the revised Kuparuk River Unit sources did not exceed significance levels near CPF-1 or other facilities in the Kuparuk River Unit. Therefore, no further annual modeling analysis is required. Table 4-1 shows the annual SO_2 screening results compared to the significance levels.

TSP

Particulate matter emissions from the Prudhoe Bay sources did not predict annual average TSP concentrations exceeding the annual significance level at Prudhoe Bay receptors.

Annual TSP concentrations from the revised Kuparuk River Unit sources are predicted to exceed the annual significance level only at receptors in the Kuparuk River Unit. In the modeling analysis, therefore, only impacts from the Kuparuk sources on the Kuparuk River Unit were considered. Values greater than 1.0 $\mu g/m^3$ are predicted to occur near CPF-1, CPF-2, and CPF-3. These locations were further examined in the refined modeling. Table 4-1 shows the annual TSP screening results compared to the significance level.

4.2.2 Short-Term Screening

Emissions of SO_2 and PM from all Kuparuk River Unit sources were input to the ISCST model to determine areas of short-term significant impact. The model was run in its rural mode with the building wake effects option selected. The ISCST source inventory modeled is identical to the ISCLT source inventory. As discussed previously this configuration is conservative.

SO_2 and PM emissions were totaled for each facility and the facilities were then ranked according to total emissions. CPF-1 will have the greatest emissions of SO_2 and PM. CPF-2 will have slightly greater emissions of SO_2 and PM than CPF-3. Therefore, for the purposes of this screening analysis, if significance levels at CPF-2 were exceeded it is likely that they would also be exceeded near CPF-1 and CPF-3. Polar coordinate receptor grids were constructed around the CPF-1 and CPF-2 with the sources colocated at the center of the grids. These receptor areas were chosen because the maximum SO_2 and TSP impacts will occur near the two facilities with the largest SO_2 and PM emission rates. For this screening analysis, receptors were spaced at distances of 0.1 and 0.25 km from the origin along radials spaced 20 degrees apart.

SO_2

The screening for short-term SO_2 impacts was performed with the ISCST model using one year of meteorological data and emissions from sources at CPF-1. Worst-case days identified by this procedure were used in the refined modeling. A similar model run for CPF-2 was also performed. Modeling results for the Kuparuk River Unit sources show the 24-hour SO_2 concentration will exceed the short-term significance level at CPF-1 only. The 24-hour significance levels for SO_2 will not be exceeded in the vicinity of other facilities. Therefore, a refined impact analysis for 24-hour SO_2 concentrations is necessary only near CPF-1.

Predicted concentrations for the revised Kuparuk River Unit sources did not exceed the 3-hour significance level for SO_2 at CPF-1 or CPF-2, therefore no refined 3-hour average impact analysis is necessary.

TSP

Model predictions of 24-hour TSP concentrations show that TSP levels due to emissions from the revised Kuparuk River Unit sources will exceed the significance level of 5 $\mu g/m^3$ near CPF-1, CPF-2, and CPF-3. Therefore more refined modeling of 24-hour TSP impacts on the NAAQS and the PSD increments is necessary. Worst-case days identified for the CPF-1 and CPF-2 in the screening analysis were used in the refined modeling. The results of the short-term screening analysis are presented in Table 4-1.

CO

CO emissions were not modeled for the revised Kuparuk River Unit sources. Since the original PTPLU modeling was highly conservative and total CO emissions actually decreased when compared with the original permit application, the maximum predicted impact would decrease.

The worst-case 1-hour CO level presented in the original permit application was about 757 $\mu g/m^3$ (Table 4-1). This highly conservative prediction is well below the 2000 $\mu g/m^3$ 1-hour significance level. When added to the background concentration of 171 $\mu g/m^3$ the total 1-hour CO concentration of 928 $\mu g/m^3$ falls well below the NAAQS levels of 40,000 $\mu g/m^3$ for a 1-hour period and 10,000 $\mu g/m^3$ for an 8-hour period. Therefore, no further CO analyses were warranted.

Ozone

Ozone impacts due to the revised Kuparuk River Unit sources were not modeled because emissions of total organic compounds decreased from those proposed in the original permit application.

Potential emissions of total organic compounds proposed in revised Kuparuk River Unit permit application will be approximately 510 tons per year. Emissions of total organic compounds proposed in the original permit application were 640 tons per year. This compares to existing total hydrocarbon emissions of 1671 tons per year calculated for sources in the Prudhoe Bay area. Since the maximum 1-hour ozone level monitored in the Prudhoe Bay unit falls well below the primary and secondary NAAQS for ozone, it is highly unlikely that the small relative increase in hydrocarbon emissions from the revised Kuparuk sources will measurably affect existing levels of ozone.

Elevated ozone levels are commonly associated with large urban areas far away from the Kuparuk River Unit. Ozone formation and its subsequent build-up is dependent in part on hydrocarbon/nitrogen oxides ratios, solar radiation, humidity, and temperature (Revlett, 1977). The amount of ozone formed in the photochemical process is dependent not only on the absolute concentration of hydrocarbons and nitrogen oxides, but also on their ratios. It is reasonable to assume that the concentrations of these pollutants will be proportional to their emissions. The Kuparuk sources will emit much larger quantities of NO_x than hydrocarbons. If NO_x levels are high and hydrocarbons low, little ozone is produced (Westberg, 1978).

Although a precise relationship between levels of NO_x and ozone cannot be defined, quantitative estimates can be made. One study (Miller, 1978) provides field confirmation of laboratory findings which indicate that when the hydrocarbon/NO_x ratio is less than 8/1, peak ozone levels are inversely proportional to the NO_x level. Since the NO_x emissions from the revised Kuparuk River Unit sources will be larger than the hydrocarbon emissions by more than a factor of 20, the hydrocarbon/NO_x ratio is much less than the critical 8/1. Thus, it is reasonable to assume that peak ozone concentrations will decrease as the NO_x concentration increases.

A study of a large source of hydrocarbons (9000 TPY) showed a relatively small (less than 10 ppb, in plume) increase in ozone, and indicated that the emissions had little effect on ambient oxidant levels (Westberg, 1978).

The extreme meteorological conditions of the Kuparuk River Unit also inhibit ozone formation. The intensity of solar radiation is an important parameter as it governs the photolysis rate of nitrogen dioxide, the reaction that initiates and sustains the oxidant formation process. With a maximum solar angle (elevation of sun with respect to the horizon) of approximately 45°, the light intensity at the Kuparuk River Unit is low, restricting ozone formation. The low temperature and humidity which are common to the area also constrain the build-up of ozone.

4.3 Refined Modeling

4.3.1 Annual

NO_2

NO_x emissions from all existing, permitted, and proposed Prudhoe Bay sources and all Kuparuk River Unit existing, previously licensed, and proposed sources were examined in refined ISCLT modeling analyses to determine maximum impacts.

The maximum annual impacts of all Kuparuk and Prudhoe Bay sources were determined from model predictions for 8x5 receptor grids with 0.25 km spacings constructed around CPF-1, CPF-2, and CPF-3. Also, a 10x10 grid with a 2 km receptor spacing, and a 4x4 grid with 1 km receptor spacing, covering the Kuparuk River Unit was examined for these sources. Finally, receptors near GC-2 and FS-1 were examined to determine the NO_x total concentrations in the Prudhoe Bay Unit.

The sources were divided into four groups for impact determination. The first group included all revised sources in the Kuparuk River Unit. Group two included the Kuparuk River Unit existing and previously licensed sources. The third group examined air quality impacts due to the Prudhoe Bay sources. The fourth source group included all the Prudhoe Bay sources as well as all sources in the preceeding groups.

The ozone limiting method described by Cole and Summerhays (1979) and recommended in the 1980 draft EPA modeling guidelines was applied to determine maximum annual NO_2 levels from the predicted NO_x concentrations. This technique limits the formation of NO_2 to an in-stack conversion component and an atmospheric conversion component. The atmospheric component cannot exceed the maximum predicted volumetric concentration of ozone. Maximum annual ozone concentrations were determined from existing measured annual average ozone levels using the technique discussed in the PSD Permit Application for New Sources to be Added to Existing and Previously Permitted Facilities in the Prudhoe Bay Unit (PSD IV).

Predicted NO_2 concentration distribution due to emissions from revised Kuparuk sources alone and for all Kuparuk and Prudhoe Bay sources are illustrated in Figures 4-1 and 4-2. Results of the modeling analysis are compared to the NAAQS for NO_2 in Table 4-2. Examination of Table 4-2 shows that the total NO_x emissions from all sources including the revised Kuparuk River Unit facilities will not result in a violation of the NAAQS for NO_2.

TSP

The screening analysis discussed in Section 4.2 identified the Kuparuk River Unit facilities CPF-1, CPF-2, and CPF-3 as needing refined modeling.

An 8x5 receptor grid was modeled with a 0.25 km spacing around each facility for all Kuparuk River Unit sources. The maximum predicted TSP impacts are shown in Table 4-3. The incremental increase in maximum annual TSP concentration due to the revised Kuparuk River Unit sources should be only about 2.8 $\mu g/m^3$. Total

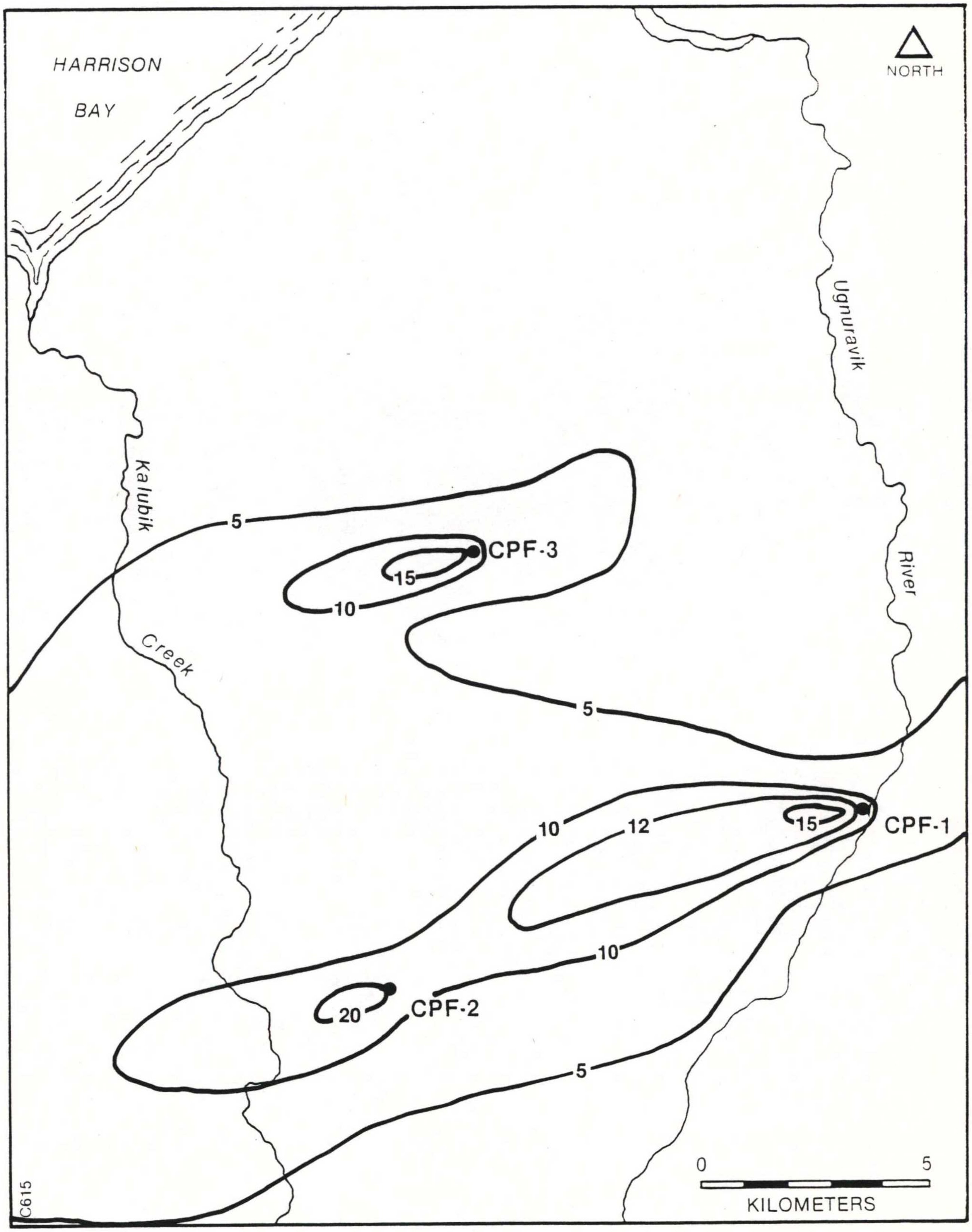

Figure 4-1. Predicted Annual NO_2 Concentrations ($\mu g/m^3$) for the Revised Kuparuk River Unit Sources

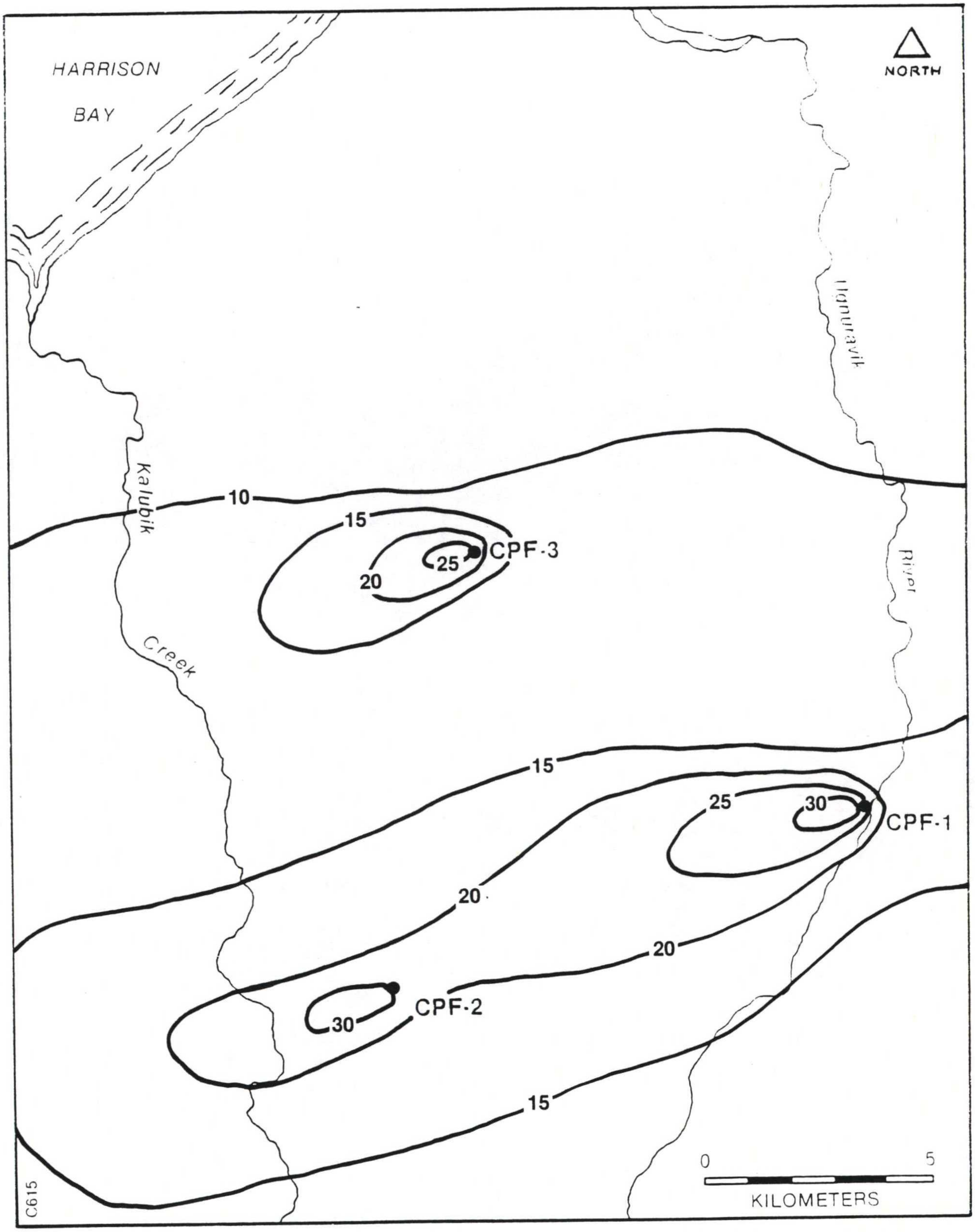

Figure 4-2. Predicted Annual NO_2 Concentrations ($\mu g/m^3$) for all Kuparuk River Unit Sources and Prudhoe Bay Sources

TABLE 4-2

MAXIMUM PREDICTED ANNUAL NO_2 CONCENTRATIONS ($\mu g/m^3$)

Pollutant Sources	Maximum Impact Receptors in the Kuparuk Area: CPF-1 Area	Maximum Impact Receptors in the Kuparuk Area: CPF-2 Area	CPF-3 Area	Maximum Impact Receptors in Prudhoe Bay Area
Background	2.0	2.0	2.0	2.0
Kuparuk Revised Sources[1]	4.0	5.5	4.2	0.1
Kuparuk Existing and Previously Licensed[1]	1.6	0.1	0.0	0.0
All Prudhoe Bay[1]	1.0	0.9	0.6	10.2
Ozone Limited NO_2[2]	49.0	49.0	49.0	49.0
Maximum Impact on NAAQS	57.6	57.5	55.9	61.3[3]
Primary and Secondary Annual NAAQS	100.0	100.0	100.0	100.0

[1] Contribution to NO_2 due to in-stack conversion (10% of total predicted NO_x concentrations).

[2] Ozone limited atmospheric NO_2 contribution as determined in PSD Permit Application for the Prudhoe Bay Unit Owners' (PSD IV), January 1981.

PM emissions should result in concentrations well below the NAAQS and the PSD Class II increments for TSP. The results are shown in Table 4-3.

4.3.2 Short-Term

24-Hour TSP

Emissions of particulate matter from existing and revised facilities in the Kuparuk River Unit only were examined in a refined ISCST modeling analysis to determine maximum short-term impacts on NAAQS and PSD increments. The initial screening analysis identified 24-hour periods during which TSP concentrations due to emissions from the amended sources were predicted to exceed the significance level. Meteorological conditions associated with maximum predicted 24-hour TSP concentrations occur on Julian Day 157 and are listed in Appendix E.

In the refined analysis a polar receptor grid with two rings (0.1 km and 0.25 km) was examined around the areas of maximum concentrations identified for the 24-hour periods. These receptor areas are located in the vicinities of CPF-1 and CPF-2.

All Kuparuk River Unit PM emissions due to existing, previously licensed, and revised sources were examined for the worst-case days at CPF-1 and CPF-2. The results of this analysis are presented in Table 4-4. This table shows that maximum predicted TSP levels fall well below the concentrations permitted by the primary and secondary NAAQS and by the PSD Class II increment.

TABLE 4-3

MAXIMUM PREDICTED ANNUAL TSP

CONCENTRATIONS ($\mu g/m^3$)

Pollutant Sources	Maximum Impact Receptors in the Kuparuk Area: CPF-1 Area	Maximum Impact Receptors in the Kuparuk Area: CPF-2 Area	CPF-3 Area
Background	11.0	11.0	11.0
Kuparuk Currently Proposed	1.4	1.6	1.3
Kuparuk Existing and Previously Licensed	1.4	0.6	0.0[1]
Maximum Impact on PSD Class II Increment	2.8	2.2	1.3
Maximum Impact on NAAQS	13.8	13.2	12.3
PSD Class II Increment	19	19	19
Primary Annual NAAQS	75	75	75
Secondary Annual NAAQS	60	60	80

[1]Less than 0.1 $\mu g/m^3$.

TABLE 4-4

MAXIMUM PREDICTED 24-HOUR

TSP CONCENTRATIONS ($\mu g/m^3$)

Pollutant Sources	Maximum Impact for CPF-1 Area[1]	Maximum Impact for CPF-2 Area[2]
Background	11.0	11.0
Kuparuk Existing and Previously Licensed Sources	8.0	0.2
Kuparuk Currently Proposed Sources	20.6	16.5
Impact on PSD Class II Increment	28.6	16.7
Impact on NAAQS	39.6	27.7
Allowable 24-Hour Class II Increment	37	37
Primary 24-Hour NAAQS	260	260
Secondary 24-Hour NAAQS	150	150

[1]Location of maximum impact receptor is 100 m WSW of CPF-1 (401156., 7801215.8).

[2]Location of maximum impact receptor is 100 m WSW of CPF-2 (391340.4, 7800417.8).

24-Hour SO_2

Emissions of SO_2 from existing, previously licensed, and revised facilities in the Kuparuk River Unit were examined in a refined ISCST modeling analysis to determine maximum short-term impacts on NAAQS and PSD increments. Worst-case days identified in the screening analysis were used in the refined modeling exercise. The meteorological conditions associated with the maximum predicted 24-hour SO_2 concentrations occur on Julian Day 157 and are listed in Appendix E. The modeling was performed in the same manner as the refined modeling for 24-hour TSP impacts. From analysis of screening results, however, only CPF-1 required refined 24-hour SO_2 modeling.

The results of this analysis are presented in Table 4-5. Results show that maximum predicted 24-hour SO_2 concentrations fall below the concentrations permitted by the primary NAAQS and by the PSD Class II increment. The incremental increase due to the inclusion of the revised Kuparuk River Unit sources is predicted to be about 16 $\mu g/m^3$.

4.4 Additional Impact Analyses

4.4.1 Impacts on Visibility

Because the total emission rate of all pollutants emitted by the Kuparuk River Unit sources and the resulting regional ambient concentrations have not changed significantly since the original application, no change to the visibility analysis presented in Section 7.1 of the original application is necessary. Impacts of the revised Kuparuk River Unit sources on visibility are not expected to be discernible because of existing visibility restrictions (Arctic haze), which are believed to be caused by long-range transport of pollutants from Europe.

TABLE 4-5

MAXIMUM PREDICTED 24-HOUR

SO_2 CONCENTRATIONS ($\mu g/m^3$)

Pollutant Sources	Maximum 24-Hour Impact Area (CPF-1)[1]
Background[2]	5.0
Kuparuk Currently Proposed	5.2
Kuparuk Existing and Previously Licensed	10.3
Impact on PSD Class II Increment	15.5
Impact on NAAQS	20.5
Allowable Class II Increment	91
Primary NAAQS	365

[1]Location of maximum impact receptor is 100 m WSW of CPF-1 (401156., 7801215.8).

[2]Detection limit of instrument.

4.4.2 Impacts on Soils and Vegetation

For the reasons stated in Section 4.4.1 (above, the original analysis of impacts on soils and vegetation is still valid. Impacts on soils and vegetation are expected to be negligible.

4.4.3 Impacts of Anticipated Induced Growth

The revised Kuparuk River Unit design will not significantly affect the number of employees required to operate the plant. Therefore, the original growth impacts analysis is still valid. Impacts due to induced growth are not expected to be significant.

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APPENDIX A

KUPARUK AREA EMISSIONS INVENTORIES

Existing, Permitted, and Proposed Emissions From Other Sources

Inventories of SO_2, NO_x, and PM emissions from other existing and proposed sources were compiled for use in performing the air quality impact analyses. This appendix presents the inventories for these sources as well as the inventory for the proposed revised Kuparuk River Unit sources.

The inventories were separated into the following groups:

Group 1. Prudhoe Bay Unit Owners' Existing Sources

Group 2. Prudhoe Bay PSD I Sources (Permit No. PSD-X79-05)

Group 3. Prudhoe Bay Unit Owners' PWI/LPS/AL Sources (Permit No. PSD-X80-09)

Group 4. Prudhoe Bay Unit Owners' Waterflood Sources (Permit No. PSD-X81-01)

Group 5. Prudhoe Bay Unit Owners' Additional Sources (1980 Equipment Exchange Analysis)

Group 6. Proposed Northwest Alaska Pipeline Company Sources (Northwest Alaska Pipeline Company Application)

Group 7. Prudhoe Bay Unit Owners' Proposed Additional Sources (PSD IV)

Group 8. Kuparuk River Unit Development Existing and Previously Licensed Sources

Group 9. Kuparuk River Unit Development Proposed Sources

The inventory for Group 1 sources is identical to that reported in the Prudhoe Bay Unit Owners' Waterflood Application. This group of sources is comprised of existing oil field sources in the Prudhoe Bay Unit and existing Deadhorse area sources.

The inventory for Group 2 is similar to that reported for sources proposed in the Prudhoe Bay Unit Owners' PSD I Application. This inventory, however, does not include sources deleted from Group 2 as a result of the Prudhoe Bay Unit Owners' 1980 Equipment Exchange Analysis.

The inventories for Groups 3 and 4 are based on the emission inventories reported in the Prudhoe Bay PWI/LPS/AL Application (1980 Permit) and Waterflood Application. These inventories, however, include all changes in assumed stack parameters covered in Case 2 of the modeling analysis reported in Radian Corporation's January 14, 1980 technical document prepared for the Prudhoe Bay Unit Owners and presented to EPA Region X. These changes are also reflected in the Prudhoe Bay Unit Owners' 1980 Equipment Exchange analysis.

The Group 5 inventory includes all additional sources reported in the Prudhoe Bay Unit Owners 1980 equipment exchange analysis.

The inventory for Group 6 consists of those sources included in the PSD Permit No. PSD-X82-05 prepared by the R. M. Parsons Company for the Northwest Alaska Pipeline Company's (NWAPC) proposed gas conditioning plant. Recently, NWAPC has submitted a modified source inventory to the ADEC for review. This modified source inventory is presented in Group 6A for informational purposes only. Group 6 sources were modeled to evaluate the air quality impacts of the revised Kuparuk River Unit sources. The table shown below presents a comparison of the total emissions due to Group 6 and Group 6A sources. Group 6 sources have greater total emissions, therefore, modeling of Group 6 sources for the revised Kuparuk River Unit air quality analysis is conservative.

NWAPC PERMIT NO. PSD-X82-05 AND CURRENTLY PROPOSED EMISSIONS COMPARISON

Pollutant	Group 6 Permit No. PSD-X82-05	Group 6A Currently Proposed
NO_x	17,572.8	16,440.4
SO_2	514.5	497.2
PM	413.8	370.9
HC	789	605.5
CO	4,362.4	3,331.1

Group 7 contains the inventory for all Prudhoe Bay Unit Owner's Proposed Additional Sources (PSD IV).

Group 8 lists the inventory for all Kuparuk River Unit existing and previously licensed sources.

Group 9 contains the inventory for all the revised Kuparuk River Unit sources.

TABLE A-1

GROUP 1: PRUDHOE BAY EXISTING SOURCES

Map ID	Source ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (^oK)	DS (m)	VS (m/sec)
ACT	ARCO P-357	449.50	7794.60	.434	.009	.019	.019	.032	.006	15.2	623	1.0	10.6
ACT	ARCO P-357	449.50	7794.60	.03	.005	..003	.003	.004	..001	15.2	623	.3	10.6
ACC	ARCO P-358	448.40	7794.70	2.7	.039	.117	.117	.198	.035	15.2	623	1.0	10.6
ACT	ARCO P-136	449.30	7794.40	1.33	.00	.116	.116	.00	.17	15.2	555	1.2	10.6
ACT	ARCO P-135	449.30	7794.40	.396	.113	.038	.038	.94	.706	10.7	1033	.9	6.9
FS-1	ARCO P-138	446.10	7795.10	14.8	.186	.502	.502	4.12	1.5	13.1	644	2.5	20.1
FS-1	ARCO P-138	445.90	7795.30	2.98	.00	.025	.025	.00	..38	15.2	623	..3	10.6
FS-2	ARCO P-381	449.55	7795.60	14.8	.186	.502	.502	4.12	1.5	13.1	644	2.5	20.1
FS-2	ARCO P-381	449.45	7795.60	2.98	.00	.025	.025	.00	.38	15.2	623	.3	10.6
FS-3	ARCO P-443	440.75	7795.80	14.8	.186	.502	.502	4.12	1.5	13.1	644	2.5	20.1
FS-3	ARCO P-443	440.75	7795.60	2.98	.00	.025	.025	.00	.38	15.2	623	.3	10.6
AFC	ARCO P-325	443.70	7802.20	.578	.00	.50	.50	.00	.076	16.1	611	.9	10.6
AFC	ARCO P-324	443.70	7802.20	164.0	2.12	5.58	5.58	45.70	16.7	25.8	755	2.4	50.6
AFC	ARCO P-324	443.70	7802.20	1.53	.022	.066	.066	.113	.02	9.1	519	1.1	10.6
CC-1	SOHIO P-338	435.80	7799.50	.037	.063	.176	.095	.25	.076	7.3	1088	.5	6.9
CC-1	SOHIO P-338	435.80	7799.50	.13	.064	.16	.086	.009	.032	7.3	1088	.5	7.4
CPS	SOHIO P-185	437.50	7797.20	109.2	1.403	3.70	3.70	30.30	11.4	15.8	777	2.7	50.6
CPS	SOHIO P-183	437.50	7797.20	20.31	.258	.69	.69	5.63	2.12	15.8	777	2.7	50.6
DW	DOW P-325	447.90	7792.00	1.25	.059	.044	.044	.767	.125	3.7	721	.2	15.2
DW	DOW P-325	447.90	7792.00	.078	.16	.067	.067	.006	.004	3.7	721	.2	7.4
N1	NANA P-413	447.30	7791.00	.76	.63	.011	.011	8.82	.377	20.0	450	.9	13.7
N1	NANA P-413	447.30	7791.00	.38	.32	.006	.006	4.41	.189	20.0	450	.9	7.4
PS1	ALY. P-289	439.00	7796.00	25.1	.320	.85	.85	6.99	2.55	13.7	727	3.3	22.8
PS1	ALY. P-289	439.00	7796.00	1.04	.009	.035	.035	.289	.105	13.7	727	3.3	22.8
PS1	ALY. P-289	439.00	7796.00	1.56	.022	.067	.067	.115	.02	13.7	623	1.0	10.7
PS1	ALY. P-289	439.00	7796.00	.00	.014	.001	.001	.00	.00	7.9	1144	.4	6.9
PS1	ALY. P-289	439.00	7796.00	.062	.01	.003	.003	.001	.002	7.9	1144	.4	7.4
N2	NANA P-423	444.40	7789.40	9.66	.64	.69	.69	2.09	.77	7.6	431	.5	18.3
N2	NANA P-434	444.40	7789.40	.04	.113	.707	.707	.904	.706	10.7	1032	.9	6.9
VE	VE P-482	446.00	7791.60	7.00	.47	.50	.39	1.51	.56	7.6	421	.5	15.2
VE	VE P-482	446.00	7791.60	.195	.055	.35	.35	.47	.35	10.6	1033	.9	6.9
AOC	ARCO OPS CR	449.80	7794.60	.26	.431	.047	.035	.153	.397	12.2	971	1.1	6.9
AOC	ARCO OPS CR	449.80	7794.60	.08	.038	.018	.014	.01	.043	12.2	1366	.8	7.4
SOC	SOHIO BOC	435.80	7799.50	.063	.034	.02	.02	.007	.008	12.2	1366	.5	6.9
SOC	SOHIO BOC	435.80	7799.50	.003	.052	.002	.00	.13	.404	12.2	1088	.5	7.4
SOC	SOHIO BOC	435.80	7799.50	.20	.53	.40	.009	6.91	1.14	6.7	660	.5	18.3

TABLE A-1 (Continued)

Map ID	Source ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (^oK)	DS (m)	VS (m/sec)
CC-2	SOHIO P-374	430.00	7803.50	.03	.047	.066	.066	.187	.056	12.2	1088	.5	6.9
CC-2	SOHIO P-347	430.00	7803.50	.106	.054	.041	.041	.009	.022	12.2	1088	.5	7.4
	DH. ARPRT	445.00	7789.00	15.67	1.14	1.12	1.12	3.38	1.25	10.7	428	.6	22.8
FC	FRONTIER	445.70	7791.20	7.83	.52	.56	.56	1.69	.63	10.7	428	.5	18.3
	ACC	427.00	7801.80	2.61	.17	.19	.19	.56	.21	10.7	428	.3	18.3
FC	Downtown	446.50	7791.20	13.06	.87	.93	.93	2.82	1.04	10.7	428	.6	15.2
CC-1	SOHIO GC1	434.75	7800.90	2.83	.049	.121	.121	.20	.04	10.0	506	.6	14.2
CC-1	SOHIO GC1	434.60	7800.95	.38	.005	.02	.02	.02	.004	18.0	506	.4	8.6
CC-2	SOHIO GC2	429.95	7801.90	2.83	.049	.121	.121	.20	.04	10.0	506	.6	14.2
CC-2	SOHIO GC2	430.05	7801.90	.38	.005	.02	.02	.02	.004	18.0	506	.4	8.6
CC-3	SOHIO GC3	436.65	7798.60	2.83	.049	.121	.121	.20	.04	10.0	506	.6	14.2
CC-3	SOHIO GC3	436.60	7798.55	.38	.005	.02	.02	.02	.004	18.0	506	.4	8.6
CPS	SOHIO CPS	437.50	7797.20	.28	.005	.012	.012	.02	.004	18.0	506	.4	3.5

TABLE A-2

GROUP 2: PRUDHOE BAY UNIT OWNERS' PSD 1 SOURCES

Map ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (°K)	DS (m)	VS (m/sec)
SOHIO GC2	430.10	7801.85	35.33	.295	1.20	1.20	9.00	3.58	16.7	470	1.71	60.0
SOHIO GC3	436.70	7798.50	8.80	.077	.30	.30	2.45	.90	16.7	755	2.69	35.0
SOHIO CPS	437.50	7797.20	35.90	.304	1.25	1.25	10.31	3.77	16.7	755	2.80	42.0

TABLE A-3

GROUP 3: PRUDHOE BAY UNIT OWNERS' PWI/LPS/AL SOURCES

Map ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (°K)	DS (m)	VS (m/sec)
GC-1	434.70	7800.90	5.20	.032	.115	.115	.95	.17	16.7	830	.88	50.0
GC-1	434.75	7801.00	1.04	.006	.03	.03	.20	.03	16.7	830	.55	50.0
GC-1	434.65	7801.10	67.20	.410	1.67	1.67	12.54	2.27	16.7	470	1.71	50.0
GC-1	434.75	7801.10	2.04	.039	.115	.115	.20	.03	7.6	623	.94	10.6
GC-1	434.60	7801.05	.12	.002	.007	.007	.012	.002	18.3	623	.43	10.6
GC-1	434.65	7800.90	7.39	.142	.42	.42	.72	.127	7.6	623	.73	10.6
GC-2	429.90	7801.85	5.20	.032	.115	.115	.95	.17	16.7	830	.88	50.0
GC-2	430.00	7801.85	1.04	.006	.03	.03	.20	.03	16.7	830	.55	50.0
GC-2	430.05	7801.80	126.52	.773	3.17	3.17	23.58	4.28	16.7	470	1.71	50.0
GC-2	429.95	7801.80	3.05	.058	.17	.17	.29	.05	7.6	623	.94	10.6
GC-2	430.00	7801.75	7.39	.142	.42	.42	.72	.127	7.6	623	.73	10.6
GC-2	429.90	7801.75	.12	.002	.007	.007	.012	.002	18.3	623	.43	10.6
GC-3	436.70	7798.45	5.20	.032	.12	.12	.95	.17	16.7	830	.88	50.0
GC-3	436.65	7798.50	1.04	.006	.03	.03	.20	.03	16.7	830	.55	50.0
GC-3	436.80	7798.45	67.20	.410	1.67	1.67	12.54	2.27	16.7	470	1.71	50.0
GC-3	436.60	7798.45	2.01	.039	.115	.115	.20	.07	7.6	623	.94	10.6
GC-3	436.70	7798.40	.12	.002	.007	.007	.012	.002	18.3	623	.43	10.6
GC-3	436.75	7798.60	7.39	.142	.42	.42	.72	.127	7.6	623	.73	10.6
DRILL PAD E	437.10	7804.70	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD F	433.50	7804.40	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD G	435.00	7802.30	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD D	434.90	7799.60	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD H	430.90	7800.10	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD J	430.80	7803.20	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD M	426.40	7804.20	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD N	428.10	7802.50	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD R	428.50	7804.20	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD Q	431.00	7801.60	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD S	423.50	7804.20	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD Y	431.20	7796.80	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3

TABLE A-3 (Continued)

Map ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (°K)	DS (m)	VS (m/sec)
DRILL PAD A	434.00	7796.60	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD C	437.30	7799.70	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD X	437.00	7793.30	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
DRILL PAD B	437.00	7796.60	0.24	.005	.014	.014	.023	.004	14.0	506	.6	14.3
CCP	443.70	7802.20	18.58	.113	.46	.46	3.45	.63	16.7	470	1.71	50.0
CCP	443.70	7802.20	.63	.012	.03	.03	.06	.01	9.1	519	.5	14.1
FS-1	446.00	7795.25	7.45	.045	.18	.18	1.40	.25	16.8	748	1.0	29.7
FS-1	446.00	7795.20	80.29	.490	1.84	1.84	14.96	2.73	16.7	470	1.71	50.0
FS-2	449.55	7795.50	107.05	.654	2.45	2.45	19.96	3.62	16.7	470	1.71	50.0
FS-2	449.55	7795.40	7.45	.045	.18	.18	1.40	.25	16.8	748	1.0	29.7
FS-2	449.45	7795.50	2.39	.046	.14	.14	.23	.04	15.0	530	.9	12.0
FS-3	440.75	7795.70	107.05	.654	2.45	2.45	19.96	3.62	16.7	470	1.71	50.0
FS-3	440.65	7795.80	7.45	.045	.18	.18	1.40	.25	16.8	748	1.0	29.7

TABLE A-4

GROUP 4: PRUDHOE BAY UNIT OWNERS' WATERFLOOD SOURCES

Map ID	Source ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (^oK)	DS (m)	VS (m/sec)
SWT	SWTR TRT	443.00	7810.10	7.88	.151	.45	.45	.78	.14	28.0	530	1.4	12.0
SWT	SWTR TRT	443.00	7810.10	2.85	.055	.16	.16	.28	.05	28.0	530	1.0	12.0
IPE	E INJ PLT	445.50	7795.00	59.47	.363	1.44	1.44	11.08	2.01	21.0	450	2.4	16.2
IPW	W INJ PLT	435.00	7800.70	59.47	.363	1.44	1.44	11.08	2.01	21.0	450	2.4	16.2
IPW	W INJ PLT	435.00	7800.70	2.39	.046	.14	.14	.23	.04	15.0	530	.9	12.0
IPE	E INJ PLT	445.50	7795.00	2.39	.046	.14	.14	.23	.04	18.3	530	.9	12.0

TABLE A-5

GROUP 5: PRUDHOE BAY UNIT OWNERS' ADDITIONAL SOURCES EQUIPMENT EXCHANGE ANALYSIS

Map ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (°K)	DS (m)	VS (m/sec)
SIPW	435.00	7800.70	11.9	.073	.29	.29	2.22	.40	22.2	450	0.76	29.0
SIPW	435.00	7800.70	18.0	.342	1.04	1.04	1.70	.30	22.2	450	1.77	29.9
GC-2	429.95	7801.70	5.6	.034	.14	.14	1.04	.19	22.2	450	1.16	31.4
GC-3	436.70	7798.55	5.6	.034	.14	.14	1.04	.19	22.2	450	1.16	31.4
STP	443.00	7810.10	7.2	.137	.41	.41	.68	.12	22.2	450	0.91	14.4
SIPE	445.50	7795.00	11.9	.073	.29	.29	2.22	.40	22.2	450	0.76	29.0
SIPE	445.50	7795.00	18.0	.342	1.04	1.04	1.70	.30	22.2	450	1.77	29.9
SIPE	445.50	7795.00	18.6	.114	.45	.45	3.47	.63	22.2	450	1.77	29.9

TABLE A-6

GROUP 6: NORTHWEST ALASKAN PIPELINE COMPANY PERMITTED SOURCES

Map ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (°K)	DS (m)	VS (m/sec)
AGCF	443.13	7802.39	38.53	.76	.74	.74	9.24	1.68	28.96	605.2	3.81	15.24
AGCF	443.17	7802.20	38.53	.76	.74	.74	9.24	1.68	28.96	605.2	3.81	15.24
AGCF	443.12	7802.40	21.98	.44	.42	.42	4.94	.90	28.96	609.7	2.89	15.24
AGCF	443.16	7802.21	21.98	.44	.42	.42	4.94	.90	28.96	609.7	2.89	15.24
AGCF	443.30	7802.33	96.31	1.90	1.85	1.85	23.10	4.20	28.96	605.2	3.81	15.24
AGCF	443.38	7802.05	128.64	2.52	2.52	2.52	30.96	5.64	28.96	605.2	4.02	15.24
AGCF	443.31	7802.15	42.88	.84	.84	.84	10.32	1.88	28.96	605.2	4.02	15.24
AGCF	443.31	7802.11	16.47	.32	.32	.32	3.76	.66	28.96	781.3	2.84	15.24
AGCF	443.07	7802.24	79.29	1.56	1.53	1.53	19.08	3.48	28.96	605.2	4.47	15.24
AGCF	443.23	7801.97	3.51	.99	.45	.45	.48	.09	38.10	421.9	1.16	15.24
AGCF	443.22	7801.97	7.44	2.07	.93	.93	1.05	.19	38.10	449.7	1.74	15.24
AGCF	443.33	7802.21	6.51	1.83	.81	.81	.93	.17	38.10	421.9	1.58	15.24
AGCF	441.50	7802.40	.30	.012	.01	.01	.011	.002	28.96	421.9	0.53	15.24
AGCF	441.60	7802.30	.35	.05	.05	.05	.00	.00	28.96	421.9	0.15	3.05
AGCF	441.60	7802.40	1.42	.016	.05	.05	.58	.107	28.96	605.7	0.86	15.24
AGCF	439.50	7796.80	.16	.05	.05	.05	1.14	.20	28.96	605.7	0.49	15.24

TABLE A-6 (CONTINUED)

GROUP 6A: CURRENTLY PROPOSED NORTHWEST ALASKAN PIPELINE COMPANY SOURCES

Map ID	UTM (km) East	North	NO_x (g/s)	SO_2 (g/s)	PM (g/s)	HS (m)	TS (°K)	DS (m)	VS (m/s)
1	442.887	7802.753	19.3	0.006	0.43	25.0	598.0	4.38	15.24
2	442.625	7802.357	39.2	0.70	0.72	36.9	583.0	3.74	15.39
3	443.038	7802.445	61.2	1.11	1.17	36.9	591.3	3.89	15.24
4	442.659	7802.357	34.4	0.62	0.64	35.1	571.9	3.52	15.24
5	442.973	7802.424	34.4	0.62	0.64	35.1	571.9	3.52	17.37
6	442.735	7802.223	110.5	2.05	2.05	38.1	598.0	3.94	17.37
7	442.909	7802.238	86.0	1.56	1.60	27.7	598.0	3.94	15.24
8	442.671	7802.668	71.1	1.32	1.32	24.1	699.7	4.77	15.24
9	442.958	7802.553	11.6	6.01	1.44	27.3	500.8	2.44	15.24
10	442.716	7802.561	4.78	0.30	0.60	24.7	557.4	1.75	15.24
11	441.739	7802.213	0.34	0.00	0.04	15.2	866.3	0.51	15.24
12	442.424	7802.495	0.113	0.00	0.02	6.4	499.7	0.14	15.24
13	441.738	7802.110	0.037	0.00	0.00	6.4	499.7	0.13	15.24
14	439.576	7795.689	0.02	0.00	0.00	15.2	499.7	0.13	15.24

TABLE A-7

GROUP 7: PRUDHOE BAY UNIT OWNERS' PROPOSED ADDITIONAL SOURCES

Map ID	UTM (km) East	UTM (km) North	NO_x Annual (g/s)	SO_2 (g/s)	Particulate Short Term (g/s)	Particulate Annual (g/s)	CO (g/s)	NMHC (g/s)	HS (m)	TS (°K)	DS (m)	VS (m/sec)
GC-1	434.70	7800.95	11.53	.068	.28	.28	2.08	.38	22.2	450	1.16	31.4
GC-1	434.65	7801.00	26.90	.159	.66	.66	4.85	.88	22.2	450	1.98	33.2
GC-2	430.05	7801.70	17.29	.102	.43	.43	3.12	.57	22.2	450	1.16	31.4
GC-2	430.10	7801.75	34.59	.204	.85	.85	6.24	1.13	22.2	450	1.98	33.2
GC-3	436.75	7798.50	5.76	.034	.14	.14	1.04	.19	22.2	450	1.16	31.4
GC-3	436.80	7798.55	46.12	.272	1.13	1.13	8.32	1.51	22.2	450	1.98	33.2
IPW	435.00	7800.70	19.22	.113	.47	.47	3.47	.63	22.2	450	1.98	33.2
FS-1	446.00	7795.15	3.84	.023	.09	.09	.69	.13	22.2	450	1.16	31.4
FS-1	445.90	7795.10	3.02	.057	.17	.17	.29	.05	22.2	450	.91	14.4
FS-1	446.10	7795.30	27.67	.163	.68	.68	4.99	.91	22.2	450	1.98	33.2
FS-2	449.45	7795.40	7.69	.045	.19	.19	1.39	.25	22.2	450	1.16	31.4
FS-3	440.65	7795.70	7.69	.045	.19	.19	1.39	.25	22.2	450	1.16	31.4
FS-3	440.65	7795.60	3.02	.057	.17	.17	.29	.05	22.2	450	.91	14.4
SWT	443.00	7810.10	24.60	.145	.60	.60	4.44	.81	22.2	450	.76	29.0

TABLE A-8

GROUP 8: KUPARUK RIVER UNIT DEVELOPMENT EXISTING AND PREVIOUSLY LICENSED SOURCES

Map ID	Description	UTM (km) East	UTM (km) North	NO_x g/s	SO_2 g/s	PM g/s	CO g/s	HC g/s	HS (m)	TS (°K)	DS (m)	VS (m/s)
CPF	4-5 MHP turbines w/WHR	401.25	7804.24	13.6	0.08	0.28	2.72	0.48	18.4	475	1.2	29.9
CPF	2-14 MHP turbines w/WHR	401.25	7804.24	19.4	0.1	0.42	3.88	0.70	24.4	500	2.2	22.4
CPF	5-10 MMBtu/hr heaters	401.24	7804.25	1.3	0.02	0.085	0.094	0.015	17.4	450	0.8	8.6
CPF	1-20 MMBtu/hr heater	401.24	7804.25	0.53	0.008	0.034	0.039	0.007	26.2	450	0.9	6.0
CPF	1-1300 lb/hr incinerator	401.24	7804.25	0.25	0.2	0.58	0.82	0.025	12.8	1255	0.76	15.4

TABLE A-9

GROUP 9: KUPARUK RIVER UNIT DEVELOPMENT REVISED SOURCES

Map ID	UTM (km) East	UTM (km) North	NO_x (g/s)	SO_2 (g/s)	PM (g/s)	CO (g/s)	HC (g/s)	HS (m)	TS (°K)	DS (m)	VS (m/s)
CPF-1	401.25	7804.25	20.8	0.12	0.42	4.08	0.72	18.4	475	1.2	29.9
	401.25	7804.25	29.1	0.15	0.63	5.8	1.05	24.4	500	2.2	22.4
	401.25	7804.25	188.5	0.96	4.09	37.68	6.89	24.4	500	2.2	43.9
	401.25	7804.25	5.5	0.08	0.36	0.40	0.06	17.4	450	0.8	8.2
	401.25	7804.25	0.5	0.015	0.089	0.078	0.014	26.2	450	0.9	6.0
	401.25	7804.25	0.23	0.121	0.345	0.486	0.151	12.8	1255	0.76	15.4
CPF-2	391.43	7800.45	34.65	0.20	0.70	6.8	1.19	18.4	475	1.2	29.9
	391.43	7800.45	38.79	0.20	0.84	7.72	1.4	24.4	500	2.2	22.4
	391.43	7800.45	2.27	0.068	0.306	0.32	0.03	17.4	450	0.8	8.2
	391.43	7800.45	0.25	0.008	0.084	0.04	0.01	26.2	450	0.9	5.7
CPF-3	393.00	7810.00	34.65	0.20	0.70	6.8	1.19	18.4	475	1.2	29.9
	393.00	7810.00	48.49	0.25	1.05	9.66	1.75	24.4	500	2.2	22.4
	393.00	7810.00	2.27	0.068	0.306	0.32	0.03	17.4	450	0.8	8.2
	393.00	7810.00	0.25	0.008	0.034	0.04	0.01	26.2	450	0.9	5.7

APPENDIX B

EMISSIONS CALCULATIONS

PROJECT NAME - Kuparuk River Unit

Combustion Calculation

Fuel Composition supplied by Arco:

Component	Molecular Weight	Mole %
CO_2	44.1	1.3
N_2	28.016	0.7
CH_4	16.043	78.0
C_2H_6	30.070	10.0
C_3H_8	44.097	10.0
H_2S	34.00	0.002 (20 ppm) negligible

Heating Value of Fuel = 1100 Btu/scf @ 25°C, 1 atm
(supplied by Arco)

$$PV = nRt$$

$$V = \frac{nRt}{P}$$

$$V = \frac{(\text{lb mole})(1.31 \text{ atm ft}^3/\text{lb mole}^\circ K)(298.2^\circ K)}{1 \text{ atm}}$$

$$V = 390.6 \text{ scf/lb mole fuel @ } 298.2^\circ K, 1 \text{ atm}$$

$0.78 + 1.56$		$0.78 + 1.56$	(moles)
$CH_4 + 2O_2$	$\rightarrow$	$CO_2 + 2H_2O$	
$0.1 + 0.35$		$0.2 + 0.3$	
$C_2H_6 + 3.5O_2$	$\rightarrow$	$2CO_2 + 3H_2O$	
$0.1 + 0.5$		$0.3 + 0.4$	
$C_3H_8 + 5O_2$	$\rightarrow$	$3CO_2 + 4H_2O$	
$0.98 + 2.41$	$\rightarrow$	$1.28 + 2.26$	(mole totals)

PROJECT NAME - Kuparuk River Unit

Combustion Calculation (based on fuel analysis supplied in original Kuparuk permit application).

We have that;

$$\underbrace{(0.02 \text{ inert} + 0.98 \text{ moles})}_{\text{Fuel}} + \underbrace{2.41 \text{ moles}}_{O_2} \rightarrow \underbrace{1.28 \text{ moles}}_{CO_2} + \underbrace{2.26 \text{ moles}}_{H_2O} + \underbrace{0.02 \text{ moles}}_{\text{inert fuel}}$$

From the Above Equation:

2.41 moles O_2 req'd (theoretical)/mole fuel

Theoretical air = $\underset{O_2}{21\%} + \underset{N_2}{79\%}$

Theoretical $N_2 = \frac{79}{21} O_2 = \frac{79}{21}(2.41) = 9.07$ moles N_2 req'd/mole fuel

Theoretical air = $\overset{O_2}{2.41} + \overset{N_2}{9.07} = 11.48$ moles/mole fuel

Excess air = $.15 \times$ T.A.
= $.15 \times 11.48$ 1.72 moles

Known:	IN	OUT	
	Fuel 1 mole	CO_2 (a)	1.28
	T.A. 11.48		
	E.A. 1.72	H_2O (a)	2.26
		N_2 (b)	9.07
		E.A. (c)	1.72
		Fuel inert (d)	0.02
		Total flue gas/mole fuel	14.35

(a.) formed from fuel and oxygen in the air
(b.) Nitrogen from theoretical air passes thru (inert).
(c.) Excess air does not react.

or

14.35 SCF flue gas/SCF fuel

PROJECT NAME - Kuparuk River Unit

Sample Calculation of Exit Velocity

$$\frac{4727 \text{ scf fuel}}{\text{hr}} \times \frac{14.25 \text{ scf flue}}{\text{scf fuel}} = 67832.5 \text{ scf flue/hr}$$

$$Q = 67832.5 \text{ scf flue gas/hr} \times \frac{\text{hr}}{60 \text{ min}}$$

$$\frac{\text{min}}{60\text{s}} \times \frac{450°\text{K}}{298°\text{K}} \times \frac{\text{m}^3}{35.31 \text{ ft}^3} = 0.806 \text{ m}^3/\text{s}$$

$Q = 0.81 \text{ m}^3/\text{s}$ $\qquad$ $D = 0.56 \text{ m}$

$Q = \frac{\pi}{4} D^2 \; Vs$ $\qquad$ $Vs = \frac{(4)Q}{\pi D^2}$

$Vs = 3.29 \text{ m/s}$

PROJECT NAME - Kuparuk River Unit

Gas Heater Emission Calculations

The potential emissions of pollutants from gas heaters were calculated using the following equation:

$$\underset{\text{Rate}}{\text{Emission (TPY)}} = \underset{\text{of Heater}}{\text{Heat Rate}^{(1)}} \times \frac{\text{scf}}{1100\ \text{Btu}} \times \frac{8760\ \text{hr}}{\text{yr}} \times \text{EF}^{(2)} \times \frac{\text{ton}}{2000\ \text{lb}}$$

Emission factors were taken from Table 1.4-1
Emission factors were taken from Table 1.4-1 of AP-42.

PM = 15 $lb/10^3\ ft^3$ Highest of 5-15 range

CO = 17 $lb/10^3\ ft^3$;

HC (as CH_4) = 3 $lb/10^3\ ft^3$;

NO_x (as NO_2) = 0.1 lb/MMBtu(3)

---

(1) Fired Duty

(2) EF = Emission Factor $\frac{\text{lbs pollutant}}{10^3 ft^3 \text{ gas burned}}$

(3) NO_x emission factor from the approved original Kuparuk PSD permit.

PROJECT NAME - Kuparuk River Unit

SO_2 Emission Factor for Gas Combustion

Emission Assumptions:

1. H_2S in fuel = 20 ppm
2. $H_2S + 3/2\ O_2 \rightarrow SO_2 + H_2O$
3. 1 mole H_2S = 1 mole SO_2
4. Standard Conditions = 25°C, 1 atm

$$SO_2 \text{ Emission Factor} = \frac{20 \text{ lb moles } H_2S}{10^6 \text{ lb moles fuel}} \times \frac{\text{lb mole } SO_2}{\text{lb mole } H_2S} \times 64 \frac{\text{lb } SO_2}{\text{lb mole } SO_2} \times$$

$$\frac{\text{lb mole fuel}}{390.6 \text{ scf}} = \frac{3.3 \text{ lb } SO_2}{10^6 \text{ scf}} \times \frac{\text{scf}}{1100 \text{ Btu}}$$

$$= 0.0030 \frac{\text{lb } SO_2}{10^6 \text{ Btu}}$$

$$= 1.4 \frac{\text{g } SO_2}{10^6 \text{ Btu}}$$

PROJECT NAME - Kuparuk River Unit

NO_x Emissions From Gas Turbines

NO_x flue gas concentration = 150 ppmv in flue gas on a dry basis at 15% excess O_2

9433 Btu/hp-hr = maximum heat rate for turbines in this permit.

Dry

$$\frac{\text{lb moles flue gas}}{\text{hp-hr}} = \frac{9433\ \text{Btu}}{\text{hp-hr}} \times \frac{\text{lb moles fuel}}{390.6\ \text{scf fuel}} \times \frac{36.3\ \text{moles flue gas}}{\text{lb mole fuel}} \times$$

$$\times \frac{\text{scf fuel}}{1100\ \text{Btu}} = \frac{0.7969\ \text{lb moles flue gas}}{\text{hp-hr}}$$

$$\frac{\text{lb}}{1000\ \text{hp-hr}} = \frac{0.7969\ \text{lb moles flue gas}}{\text{hp-hr}} \times \frac{0.000150\ \text{lb moles}\ NO_2}{\text{lb moles flue gas}}$$

$$\times \frac{46.008\ \text{lb}\ NO_2}{\text{lb mole}} \times 1000 = \frac{5.5\ \text{lb}\ NO_x}{1000\ \text{hp-hr}}$$

$$5000\ \text{hp} \times \frac{5.5\ \text{lbs}\ NO_x}{1000\ \text{hp-hr}} = 27.5\ \frac{\text{lb}\ NO_x}{\text{hr}}$$

$$27.5\ \frac{\text{lb}\ NO_x}{\text{hr}} \times 453.59\ \frac{\text{g}}{\text{lb}} \times \frac{\text{hr}}{3600\text{s}} = 3.46\ \frac{\text{g}\ NO_x}{\text{s}}$$

Emissions of SO_2, PM, CO, and HC from the 5 MHP, 14 MHP, and 34 MHP turbines were obtained from the original Kuparuk permit application.

PROJECT NAME - Kuparuk River Unit

<u>Incinerator Emissions</u> (Waste Combustion with Supplemental Natural Gas)

Calculation factor from AP-42 Table 2.1-1 Refuse Incinerator

PM = 7 lb/ton

SO_2 = 2.5 lb/ton

CO = 10 lb/ton

HC = 3 lb/ton

NO_2 = 3 lb/ton

$$0.385 \text{ ton/hr} \times 7 \text{ lb/ton} = 2.7 \frac{\text{lb PM}}{\text{hr}} = 0.34 \text{ g/s}$$

$$0.385 \text{ ton/hr} \times 2.5 \text{ lb/ton} = 1 \frac{\text{lb } SO_2}{\text{hr}} = 0.12 \text{ g/s}$$

$$0.385 \text{ ton/hr} \times 10 \text{ lb/ton} = 3.8 \frac{\text{lb CO}}{\text{hr}} = 0.48 \text{ g/s}$$

$$0.385 \text{ ton/hr} \times 3 \text{ lb/ton} = 1.2 \frac{\text{lb HC}}{\text{hr}} = 0.15 \text{ g/s}$$

$$0.385 \text{ ton/hr} \times 3 \text{ lb/ton} = 1.2 \frac{\text{lb } NO_2}{\text{hr}} = 0.15 \text{ g/s}$$

Calculation factor from AP-42 Table 1.4-1 Natural Gas Combustion

PM = 15 lb/10^6 scf fuel

SO_2 = 3.3 lb/10^6 scf fuel (based on 20 ppm H_2S)

CO = 17 lb/10^6 scf fuel

HC = 3 lb/10^6 scf fuel

NO_2 = 230 lb/10^6 scf fuel

PROJECT NAME - Kuparuk River Unit

$$2750 \text{ scf fuel/hr} \times 15 \text{ lb}/10^6 \text{ scf fuel} = \frac{0.04 \text{ lb PM}}{\text{hr}} = 0.005 \text{ g/s}$$

$$2750 \text{ scf fuel/hr} \times 3.3 \text{ lb}/10^6 \text{ scf fuel} = \frac{0.009 \text{ lb } SO_2}{\text{hr}} = 0.001 \text{ g/s}$$

$$2750 \text{ scf fuel/hr} \times 17 \text{ lb}/10^6 \text{ scf fuel} = \frac{0.05 \text{ lb CO}}{\text{hr}} = 0.006 \text{ g/s}$$

$$2750 \text{ scf fuel/hr} \times 3 \text{ lb}/10^6 \text{ scf fuel} = \frac{0.009 \text{ lb HC}}{\text{hr}} = 0.001 \text{ g/s}$$

$$2750 \text{ scf fuel/hr} \times 230 \text{ lb}/10^6 \text{ scf fuel} = \frac{0.633 \text{ lb } NO_2}{\text{hr}} = 0.008 \text{ g/s}$$

Total Incinerator Emissions (natural gas combustion + waste combustion)

PM = 0.34 + 0.005 = 0.345 g/s

SO_2 = 0.12 + 0.001 = 1.121 g/s

CO = 0.48 + 0.006 = 0.486 g/s

HC = 0.15 + 0.001 = 0.151 g/s

NO_2 = 0.15 + 0.08 = 0.23 g/s

PROJECT NAME - Kuparuk River Unit

Incinerator Exit Velocity Calculation (CPF-1)

765 lb/hr combined waste incinerator-assumed 30% moisture

Dry combustibles = 765 lb/hr x .7 = 535.5 lb/hr

Moisture total = 765 lb/hr x .3 = $\underline{229.5 \text{ lb/hr}}$

765 lb/hr

Volume of Combustion Products in Primary Chamber

Volume through flame port with 200% x's air

267.72 scf/lb AP-40, page 446

Fuel 2750 scf fuel/hr x 14.35 scf flue gas/scf fuel gas $= 3.95 \times 10^4 \dfrac{\text{scf flue gas}}{\text{hr}}$

Garbage 535.5 lb/hr x 267.7 scf/lb $= 1.43 \times 10^5$ scf/hr

Moisture 229.5 lb/hr x $\dfrac{390.6 \text{ scf/mole}}{18 \text{ lb/mole}}$ $= \underline{4.98 \times 10^3 \text{ scf/hr}}$

1.87×10^5 scf/hr

Volume Through Secondary Chamber

Assume 50% theoretical air added. 85.12 scf/lb AP-40, page 446

535.5 lb/hr x 85.12 scf/lb x 0.5 = 22,791 scf/hr

Total = 1.87×10^5 + 22,791 scf/hr = 2.10×10^5 scf/hr

$$2.10 \times 10^5 \frac{\text{scf}}{\text{hr}} \times \frac{\text{hr}}{60 \text{ min}} \times \frac{\text{min}}{60\text{s}} = 58.3 \frac{\text{scf}}{\text{s}}$$

PROJECT NAME - Kuparuk River Unit

Incinerators (continued)

Q = Volume of Waste Combustion Products + Volume of Fuel Combustion Products

$$Q = 2.1 \times 10^5 \frac{\text{scf}}{\text{hr}} \times \frac{\text{m}^3}{35.31\ \text{ft}^3} \times \frac{\text{hr}}{3600\text{s}}$$

$$Q = 1.65\ \text{m}^3/\text{s}$$

$$A = \frac{\pi D^2}{4} \qquad D = 0.76\ \text{m}$$

$$A = \frac{\pi(0.76\ \text{m})^2}{4}$$

$$A = 0.45\ \text{m}^2$$

$$\text{Velocity} = \frac{(Q)\ (T_2)}{(A)\ (T_1)}$$

$$V = \frac{(1.65\ \text{m}^3/\text{s})(1255°\text{K})}{(0.45\ \text{m}^2)(298.2°\text{K})}$$

$$V = 15.4\ \text{m/s}$$

APPENDIX C

METEOROLOGICAL DATA
PROCESSING

DATA SOURCES

Three sources of meteorological data were used to develop the annual Joint Frequency Function (JFF) and the modified short-term PREP data files for the modeling effort:

- Prudhoe Bay meteorological monitoring data,
- Barter Island National Weather Service (NWS) upper air data, and
- Prudhoe Bay acoustic sounder mixing heights for the winter night period.

Data for the period from April 1, 1979 through March 31, 1980 were processed according to the flow diagram shown in Figure C-1. The Prudhoe Bay monitoring data that were processed include 10-meter wind direction, wind speed, and temperature measurements from the Well Pad A site (Trailer 041) and 60-meter wind direction standard deviation measurements (σ_θ) from the Sohio Tower site (Site 039).

STABILITY CLASS DETERMINATION

Hourly stability class estimates were made according to the modified σ_θ method recommended in the Guideline on Air Quality Models, Proposed Revisions (EPA OAQPS Guideline Series, October 1980), with two exceptions:

- the σ_θ measurements from 60 meters were used, with a modification of the stability class limits to apply to 60 meters, since 10 meter σ_θ measurements were not available, and

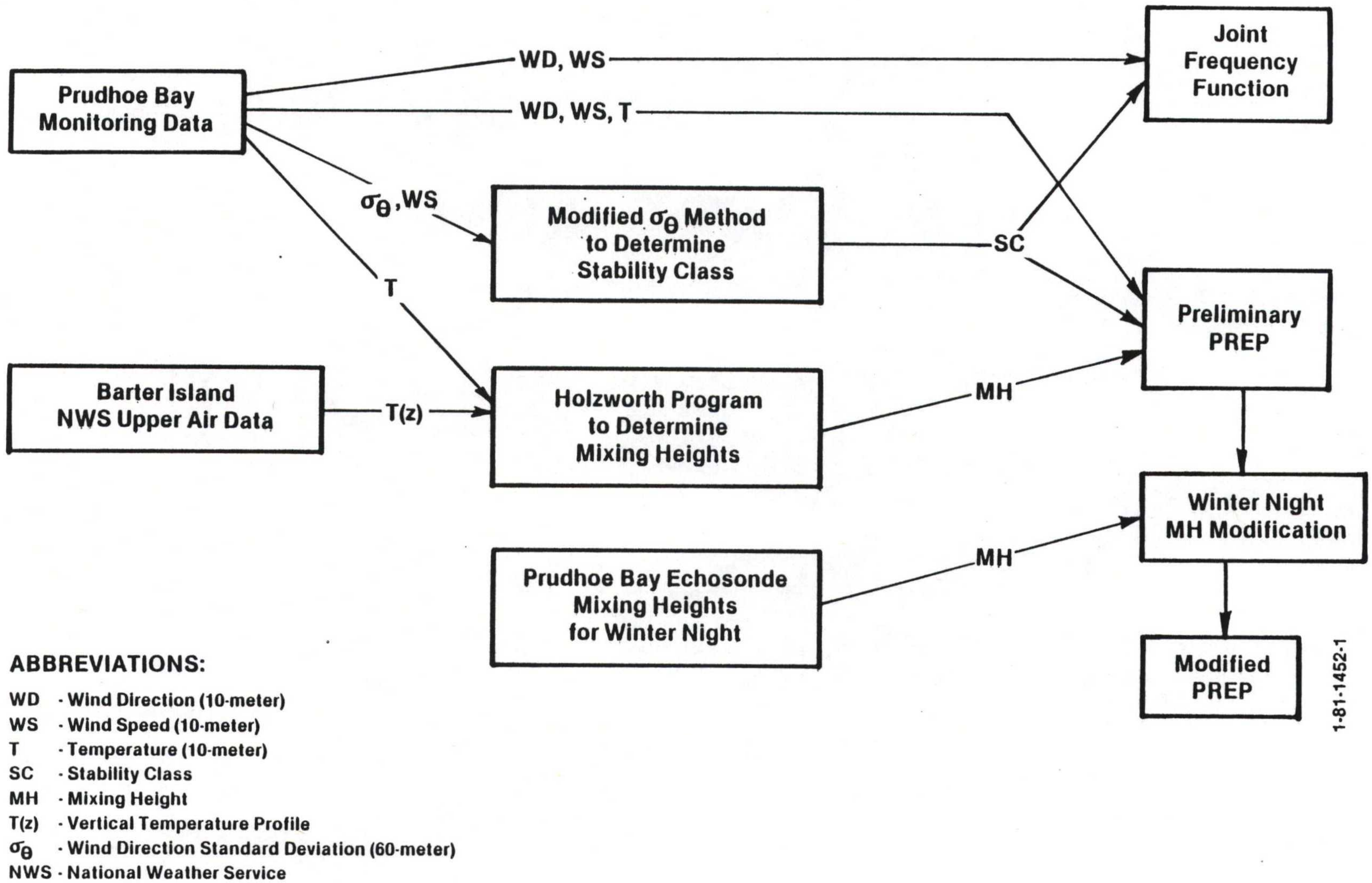

Figure C-1. Flow Diagram for Meteorological Data Processing.

- E and F stability class estimates that occurred when 10-meter wind speeds greater than 11 knots were changed to D stability.

The formula given by Sedefian and Bennett in "A Comparison of Turbulence Classification Schemes" (Atmospheric Environment, Vol. 14, pp. 741-750, 1980) was used to adjust the σ_θ stability class ranges, as follows:

$$\sigma_\theta(60\ \text{m}) = \sigma_\theta(10\ \text{m})\ (60/10)^{P_\theta}$$

$$= \sigma_\theta(10\ \text{m})\ 6^{P_\theta}$$

where P_θ = -0.06 for A stability
= -0.15 for B stability
= -0.17 for C stability
= -0.23 for D stability
= -0.38 for E stability
= -0.53 for F stability

The σ_θ ranges for 60 meters were also modified to account for the surface roughness as recommended by the modeling guidelines. A roughness parameter of Z_o = 0.27 cm was used. This roughness value was determined from 40 and 60 meter wind speed observations at the SOHIO tower, using the logarithmic profile equation. Accordingly, the multiplying factor for adjusting the σ_θ ranges for surface roughness is

$$(Z_o/15\ \text{cm})^{0.2} = 0.45$$

Following this procedure, a new set of σ_θ stability class ranges was generated and used for the Kuparuk Oil Field application:

Stability Class	Adjusted σ_θ Ranges for 60 Meters
A	$9.1° < \sigma_\theta$
B	$6.0° < \sigma_\theta \leq 9.1°$
C	$4.2° < \sigma_\theta \leq 6.0°$
D	$2.2° < \sigma_\theta \leq 4.1°$
E	$0.9° < \sigma_\theta \leq 2.2°$
F	$\sigma_\theta \leq 0.9°$

For nighttime conditions (one hour prior to sunset to one hour after sunrise) adjustments to the stability class estimates were made according to the new modeling guidelines, as follow:

If the nighttime σ_θ stability class was	And if the 10m wind speed, u, was m/s	mi/hr	Then the stability class was changed to
A	$u<2.9$	$u<6.4$	F
	$2.9\leq u<3.6$	$6.4\leq u<7.9$	E
	$3.6\leq u$	$7.9\leq u$	D
B	$u<2.4$	$u<5.3$	F
	$2.4\leq u<3.0$	$5.3\leq u<6.6$	F
	$3.0\leq u$	$6.6\leq u$	D
C	$u<2.4$	$u<5.3$	E
	$2.4\leq u$	$5.3\leq u$	D
D	wind speed not considered		D
E	wind speed not considered		E
F	wind speed not considered		F

MIXING HEIGHT DETERMINATION

The Holzworth program from the National Climatic Center was used to compute twice-daily mixing heights based on the vertical temperature profiles from Barter Island in conjunction with 10-meter temperatures monitored at Prudhoe Bay. These twice daily mixing heights were input to the PREP preprocessor program to calculate hourly mixing heights for the one-year period. PREP was not designed to handle situations in which the meteorological data are collected at a monitoring site above the Acrtic Circle. Therefore, PREP was modified to handle the impact of the circumpolar sun on processing meteorological data. These modifications are identical to those discussed in the Unit Owners' Waterflood Application.

Hourly mixing heights produced by the modified PREP program were used for the entire period except for October 2, 1979 through February 2, 1980 when the maximum daily sun elevation above the horizon was less than about 10 degrees. The PREP determination of mixing heights is not applicable to the winter nighttime conditions that occur at the Kuparuk Oil Field because it assumes that unstable conditions occur each day due to solar heating. For the winter nighttime period, mixing height measurements made by an acoustic sounder at Prudhoe Bay were used. Only mixing heights identified with a capping elevated inversion were used in this case. For times during the winter period where a capping inversion was not present, the mixing height was considered to be undefined and an arbitrary, large volume of 5,000 meters was used.

The annual mixing height for long-term modeling was determined by averaging the Holzworth determined afternoon mixing heights. An annual average value of 300 meters was calculated.

APPENDIX D

DISPERSION MODELS

ISC

The Industrial Source Complex (ISC) Gaussian dispersion model (Bowers et al, 1979) is a set of two computer programs that can be used to assess the air quality impact of emissions from the wide variety of sources associated with an industrial source complex. The short-term version of ISC is ISCST and is used to predict short-term ambient concentrations. The long-term version of ISC is ISCLT and is used to predict annual or seasonal average ambient concentrations. The ISC model is designed for use with non-reactive pollutants. ISC is a multiple source model capable of predicting the interactive impacts of groups of sources under either rural or urban conditions and in flat or gently rolling terrain. Sources can be either point sources, volume sources, or area sources.

Briggs' plume rise formulas (Briggs, 1971, 1975) are incorporated into ISC and allow for the computation of distance-dependent and final plume rise for both buoyancy and momentum dominated plumes. In addition, ISC accounts for the effects of stack tip aerodynamic downwash and the effects of aerodynamic wakes and eddies formed by buildings and other structures on plume dispersion (Huber and Snyder, 1976) (Huber, 1977).

The ISC dispersion model is designed to calculate the effects of gravitational setting and dry deposition for plumes containing particulate matter and dry deposition for plumes containing gaseous pollutants. Alternately, the ISC model can calculate total dry deposition in lieu of ambient concentrations. A wind-profile exponent law is used to adjust the observed wind speed from the measurement height to the physical emission height for plume rise and concentration calculations. The Pasquill-Gifford curves (Turner, 1970) are used to calculate lateral (σ_y) and vertical (σ_z) plume spread.

The ISCST model uses sequential hourly inputs of ambient temperature, wind speed, wind direction, stability class, and mixing height to compute concentration or deposition values for averaging periods from 1 to 24 hours. If used with a season or year of sequential hourly meteorological data, ISCST will calculate seasonal or annual concentrations or depositions.

The ISCLT model uses a seasonal or annual statistical summary of meteorological information in the form of a joint frequency distribution of wind speed, wind direction, and stability class as meteorological input. Both seasonal and annual concentration or deposition calculations can be made with ISCLT.

PTPLU

PTPLU is a short-term Gaussian dispersion model designed to predict maximum hourly concentrations as a function of wind speed and stability for point sources located in areas of flat terrain. PTPLU is an updated version of the PTMAX Gaussian dispersion model (Turner and Busse, 1973).

A separate analysis is made for each individual stack. Input to the program consists of the source emission rate, physical stack height, and stack gas temperature. Also required are the stack gas volume flow or both the stack gas velocity and inside diameter at the top of the stack. Additional inputs to the model include the height at which the meteorological data is valid and the power law exponents used to adjust the wind speed to that expected at the physical stack height.

PTPLU determines, for each wind speed and stability class, either the final or distance-dependent plume rise using methods suggested by Briggs (Briggs, 1971, 1975). This plume rise is added to the physical stack height to determine the effective height of emissions. The effective height is used to determine both the maximum concentration and the distance to maximum concentration. The plume rise calculated by PTPLU can take into account stack tip downwash, buoyancy induced dispersion, and the effects of both buoyancy and momentum on plume rise. The Pasquill-Gifford horizontal and vertical dispersion coefficients as reported by Turner (Turner, 1970) are incorporated into the model.

REFERENCES FOR APPENDIX D

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APPENDIX E

METEOROLOGICAL DATA USED IN
DISPERSION MODELING

TABLE E-1

WORST-CASE 24-HOUR METEOROLOGICAL CONDITIONS FOR TSP (DAY 157)

Hour	Wind Direction (Degrees)	Wind Speed (MPS)	Mixing Height (Meters)	Temp. (Deg. K)	Stability Category
1	110	12.0	292	271	D
2	108	11.5	299	271	D
3	109	10.9	306	270	D
4	110	11.3	313	270	D
5	108	10.7	320	270	C
6	110	10.2	327	270	D
7	109	10.4	334	270	D
8	108	11.3	341	270	D
9	109	12.1	347	270	D
10	109	12.7	354	270	D
11	109	13.1	361	271	D
12	112	13.4	368	271	D
13	111	12.8	375	271	D
14	109	12.6	382	271	D
15	105	12.1	389	272	D
16	105	12.5	396	272	D
17	107	13.4	403	271	D
18	105	13.3	410	271	B
19	105	13.0	416	271	B
20	103	12.8	423	270	B
21	100	12.9	430	270	C
22	99	12.5	437	269	D
23	101	12.9	444	269	D
24	100	12.8	451	269	D

TABLE E-2

WORST-CASE 24-HOUR METEOROLOGICAL CONDITIONS FOR SO_2 (DAY 157)

Hour	Wind Direction (Degrees)	Wind Speed (MPS)	Mixing Height (Meters)	Temp. (Deg. K)	Stability Category
1	110	12.0	292	271	D
2	108	11.5	299	271	D
3	109	10.9	306	270	D
4	110	11.3	313	270	D
5	108	10.7	320	270	C
6	110	10.2	327	270	D
7	109	10.4	334	270	D
8	108	11.3	341	270	D
9	109	12.1	347	270	D
10	109	12.7	354	270	D
11	109	13.1	361	271	D
12	112	13.4	368	271	D
13	111	12.8	375	271	D
14	109	12.6	382	271	D
15	105	12.1	389	272	D
16	105	12.5	396	272	D
17	107	13.4	403	271	D
18	105	13.3	410	271	B
19	105	13.0	416	271	B
20	103	12.8	423	270	B
21	100	12.9	430	270	C
22	99	12.5	437	269	D
23	101	12.9	444	269	D
24	100	12.8	451	269	D

TABLE E-3

ANN RELATIVE FREQUENCY DISTRIBUTION STATION =PRUDHOE BAY(1979-1980)

DIRECTION	SPEED(KTS) 0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.002231	.005988	.002583	.000352	.000000	.000000	.011154
NNE	.001174	.005753	.001996	.000000	.000000	.000000	.008923
NE	.001292	.007514	.003053	.000235	.000000	.000000	.012093
ENE	.000704	.003640	.002583	.000352	.000117	.000000	.007397
E	.000587	.003405	.002348	.000587	.000352	.000000	.007280
ESE	.001174	.001292	.001409	.000352	.000000	.000000	.004227
SE	.000470	.002231	.001879	.000000	.000000	.000000	.004579
SSE	.000235	.001644	.000822	.000000	.000000	.000000	.002700
S	.000939	.001526	.000587	.000352	.000000	.000000	.003405
SSW	.000822	.000939	.001174	.000235	.000000	.000000	.003170
SW	.000587	.003053	.001409	.000470	.000000	.000000	.005518
WSW	.000235	.001996	.001409	.000704	.000117	.000000	.004462
W	.000704	.001761	.001057	.001174	.000117	.000000	.004814
WNW	.000704	.002583	.001174	.000352	.000000	.000000	.004814
NW	.000939	.002583	.001761	.000470	.000000	.000000	.005753
NNW	.001526	.003757	.002466	.000352	.000000	.000000	.008101
TOTAL	.014324	.049665	.027709	.005988	.000704	.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = .098391
RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = .000000

ANN RELATIVE FREQUENCY DISTRIBUTION STATION =PRUDHOE BAY(1979-1980)

	SPEED(KTS)						
DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.000000	.000939	.001409	.000235	.000000	.000000	.002583
NNE	.000000	.000939	.002231	.000117	.000000	.000000	.003288
NE	.000235	.003288	.006458	.000704	.000000	.000000	.010685
ENE	.000235	.002700	.004814	.002818	.000117	.000117	.010802
E	.000235	.001879	.002583	.001526	.000117	.000470	.006810
ESE	.000117	.001292	.002935	.001292	.000000	.000117	.005753
SE	.000000	.000822	.000352	.000235	.000000	.000000	.001409
SSE	.000235	.000117	.000235	.000000	.000000	.000000	.000587
S	.000117	.000352	.000117	.000000	.000000	.000000	.000587
SSW	.000000	.000352	.001292	.000470	.000000	.000000	.002113
SW	.000117	.000704	.000939	.000235	.000117	.000000	.002113
WSW	.000235	.001057	.001174	.001057	.000235	.000117	.003875
W	.000117	.000822	.001879	.001409	.000117	.000000	.004344
WNW	.000000	.000704	.001879	.001761	.000000	.000000	.004344
NW	.000117	.000235	.000939	.000470	.000000	.000000	.001761
NNW	.000000	.000352	.000822	.000587	.000000	.000000	.001761
TOTAL	.001761	.016555	.030058	.012915	.000704	.000822	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = .062815
RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = .000000

ANN RELATIVE FREQUENCY DISTRIBUTION STATION =PRUDHOE BAY(1979-1980)

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DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
	SPEED(KTS)						
N	.000000	.000470	.000704	.000470	.000000	.000000	.001644
NNE	.000235	.000235	.001174	.000704	.000000	.000000	.002349
NE	.000117	.001879	.006340	.001996	.000117	.000000	.010450
ENE	.000235	.001057	.007045	.008454	.001996	.001879	.020665
E	.000117	.002231	.006223	.007162	.002700	.002113	.020547
ESE	.000117	.000822	.002466	.002231	.000235	.000000	.005871
SE	.000000	.000352	.002113	.000000	.000000	.000000	.002466
SSE	.000000	.000235	.000117	.000000	.000000	.000000	.000352
S	.000117	.000235	.000117	.000117	.000000	.000000	.000587
SSW	.000235	.000000	.000822	.000235	.000000	.000000	.001292
SW	.000000	.001292	.000822	.001526	.000000	.000000	.003640
WSW	.000000	.001057	.001526	.001996	.000235	.000235	.005049
W	.000000	.000587	.001996	.002700	.000704	.000352	.006340
WNW	.000000	.000117	.001409	.002466	.000822	.000117	.004931
NW	.000000	.000117	.000352	.000352	.000000	.000000	.000822
NNW	.000000	.000352	.000000	.000235	.000000	.000000	.000587
TOTAL	.001174	.011037	.033228	.030645	.006810	.004696	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = .087590
RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = .000000

ANN RELATIVE FREQUENCY DISTRIBUTION STATION =PRUDHOE BAY(1979-1980)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
			SPEED(KTS)				
N	.000715	.001644	.003757	.000704	.000000	.000000	.006820
NNE	.001068	.001526	.003288	.003288	.000117	.000000	.009287
NE	.001445	.006692	.015616	.019608	.003522	.001057	.047940
ENE	.000961	.003875	.018786	.052366	.037807	.023600	.137393
E	.001793	.005518	.018669	.046965	.033110	.042151	.148206
ESE	.000435	.003053	.009745	.009510	.004814	.000822	.028429
SE	.000476	.001057	.002818	.001292	.000000	.000000	.005643
SSE	.000355	.000352	.001761	.001644	.000000	.000000	.004113
S	.000121	.000587	.003170	.000704	.000000	.000000	.004582
SSW	.000126	.001761	.010685	.006810	.000000	.000000	.019381
SW	.000491	.004462	.018551	.022191	.005753	.002466	.053914
WSW	.000252	.003757	.017142	.033697	.012446	.011859	.079153
W	.000374	.004696	.018199	.014324	.005636	.007280	.050509
WNW	.000249	.002935	.006575	.004579	.001057	.000587	.015982
NW	.000121	.000704	.003522	.001174	.000000	.000000	.005522
NNW	.000361	.001526	.003405	.000117	.000000	.000000	.005409
TOTAL	.009333	.044147	.155688	.218974	.104262	.089820	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = .622285
RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = .000235

ANN RELATIVE FREQUENCY DISTRIBUTION STATION =PRUDHOE BAY(1979-1980)

IDIR
IDIR
IDIRI
IAAM

DIRECTION	SPEED(KTS) 0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.000359	.000470	.000704	.000000	.000000	.000000	.001533
NNE	.000601	.001174	.000939	.000000	.000000	.000000	.002715
NE	.001030	.001761	.006692	.000000	.000000	.000000	.009533
ENE	.000976	.003522	.006692	.000000	.000000	.000000	.011190
E	.000374	.002348	.005284	.000000	.000000	.000000	.008006
ESE	.000604	.001526	.001174	.000000	.000000	.000000	.003305
SE	.000121	.000352	.000000	.000000	.000000	.000000	.000473
SSE	.000006	.000704	.000000	.000000	.000000	.000000	.000710
S	.000240	.000352	.000235	.000000	.000000	.000000	.000827
SSW	.000364	.001057	.001644	.000000	.000000	.000000	.003064
SW	.000610	.002231	.006575	.000000	.000000	.000000	.009416
WSW	.000134	.001879	.006927	.000000	.000000	.000000	.008940
W	.000372	.002113	.003757	.000000	.000000	.000000	.006243
WNW	.000715	.000587	.000470	.000000	.000000	.000000	.001772
NW	.000360	.000587	.000470	.000000	.000000	.000000	.001417
NNW	.000834	.000704	.000117	.000000	.000000	.000000	.001656
TOTAL	.007749	.021369	.041681	.000000	.000000	.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = .070800
RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = .000235

ANN RELATIVE FREQUENCY DISTRIBUTION STATION =PRUDHOE BAY(1979-1980)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
	SPEED(KTS)						
N	.000587	.001292	.000000	.000000	.000000	.000000	.001879
NNE	.000587	.000939	.000000	.000000	.000000	.000000	.001526
NE	.000587	.001292	.000117	.000000	.000000	.000000	.001996
ENE	.000704	.001292	.000000	.000000	.000000	.000000	.001996
E	.000822	.003405	.000117	.000000	.000000	.000000	.004344
ESE	.001761	.003757	.000000	.000000	.000000	.000000	.005518
SE	.001761	.002348	.000000	.000000	.000000	.000000	.004109
SSE	.001409	.001292	.000000	.000000	.000000	.000000	.002700
S	.001526	.002348	.000000	.000000	.000000	.000000	.003875
SSW	.001526	.002231	.000000	.000000	.000000	.000000	.003757
SW	.001879	.005284	.000117	.000000	.000000	.000000	.007280
WSW	.002231	.002700	.000000	.000000	.000000	.000000	.004931
W	.002231	.002231	.000000	.000000	.000000	.000000	.004462
WNW	.001526	.002113	.000000	.000000	.000000	.000000	.003640
NW	.001057	.002348	.000000	.000000	.000000	.000000	.003405
NNW	.000822	.001879	.000000	.000000	.000000	.000000	.002700
TOTAL	.021017	.036750	.000352	.000000	.000000	.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF F STABILITY = .058119
RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH F STABILITY = .000000

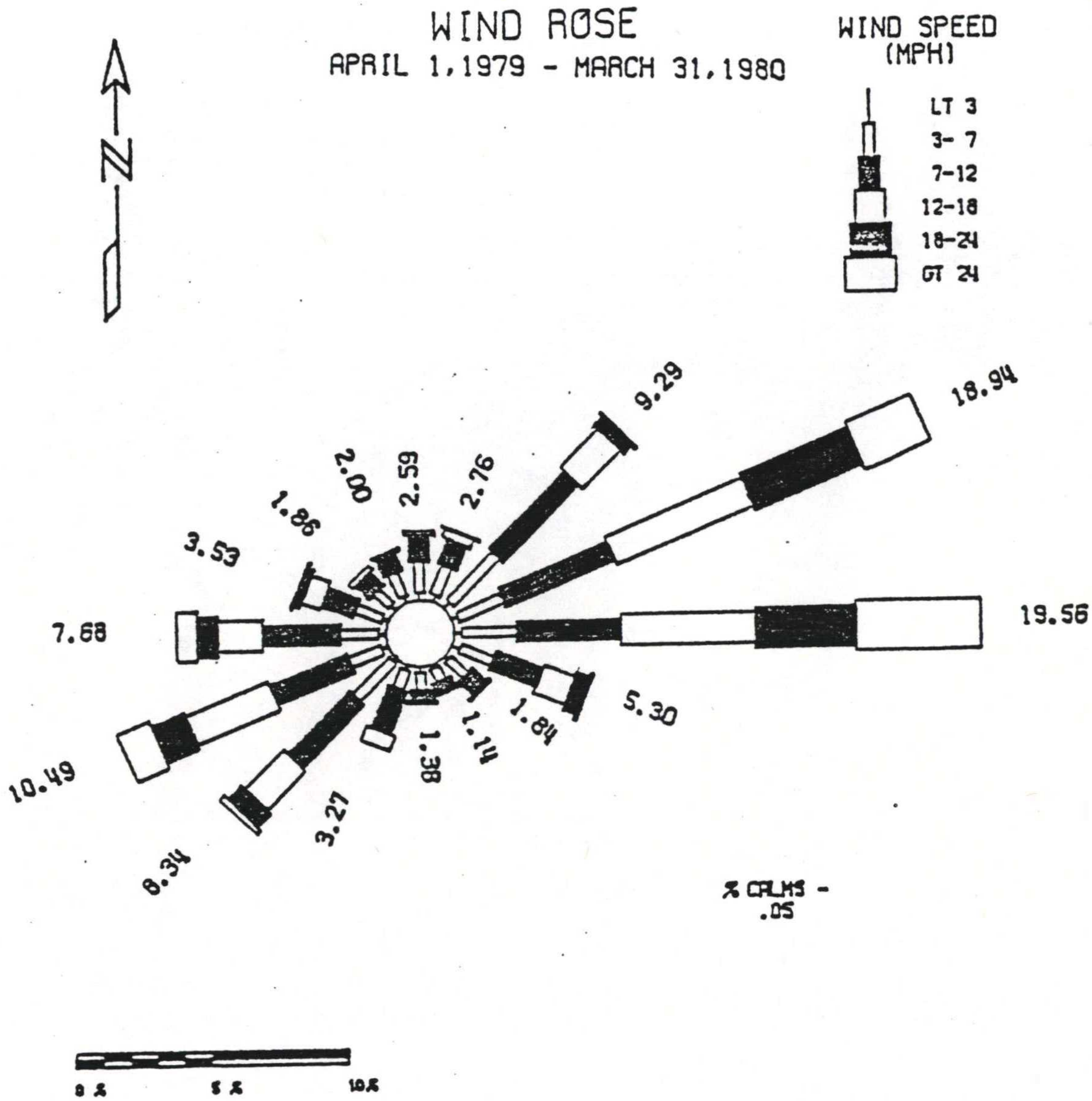
APPENDIX F
REPRESENTATIVENESS OF THE METEOROLOGICAL DATA

REPRESENTATIVENESS OF THE METEOROLOGICAL DATA

Wind directions and wind speeds used in modeling were those measured at Site 1. A wind rose (joint frequency diagram) for these data is presented in Figure F-1. For comparison purposes, wind roses for Barter Island (1958-1964), the Deadhorse Airport (1976), and Barter Island (1968-1977), are presented in Figures F-2 and F-3. The similarity of wind patterns indicated for these geographically separated locations and different time periods strongly suggests that the Prudhoe Bay Site data are representative of regional climatic conditions.

Stability class distributions for the Prudhoe Bay Monitoring Network, derived as described in Appendix C, are compared with those for Barter Island (1968-1977), which are derived by the Pasquill-Turner method, in Table F-1. When considering the differences in the bases for the stability classifications, it is concluded that the stability data from the Prudhoe Bay Network are reasonable approximations of regional conditions.

Precipitation and temperature data comparisons also indicate that the data measured at the Prudhoe Bay Monitoring Network, and used in the modeling analyses, are representative of the Kuparuk area. Precipitation data recorded during the April, 1979 to March, 1980 period at Point Barrow (3.19 inches) and Barter Island (7.20 inches) indicate a trend of increasing precipitation from west to east along the north coast of Alaska. The data for Prudhoe Bay (Site 2) for this time period (5.34 inches) is in close agreement with this trend. Temperature data recorded at the three 10-meter temperature sensors in the Prudhoe Bay Monitoring Network averaged 12.4°F. The mean annual temperature at Prudhoe Bay Airport during 1971-1973 was 7.9°F. The mean temperature at Point Barrow during the April 1979 to March 1980 period was 3.1°F higher than the climatological normal temperature established from 1941-1979; at Barter Island during the same period, the departure from the 1947-1970 climatological normal temperature was 3.3°F. This may be indicative of regional climatological change. When this difference from long-term mean temperature is considered in conjunction with the difference between 1.8-meter and 10-meter temperatures at Site 2 during the period of simultaneous measurements (more than 1°F), the Prudhoe Bay Monitoring Network data appear to be in close agreement with that expected at the Prudhoe Bay Airport.



PRUDHOE BAY - WELL PAD A

Figure F-1

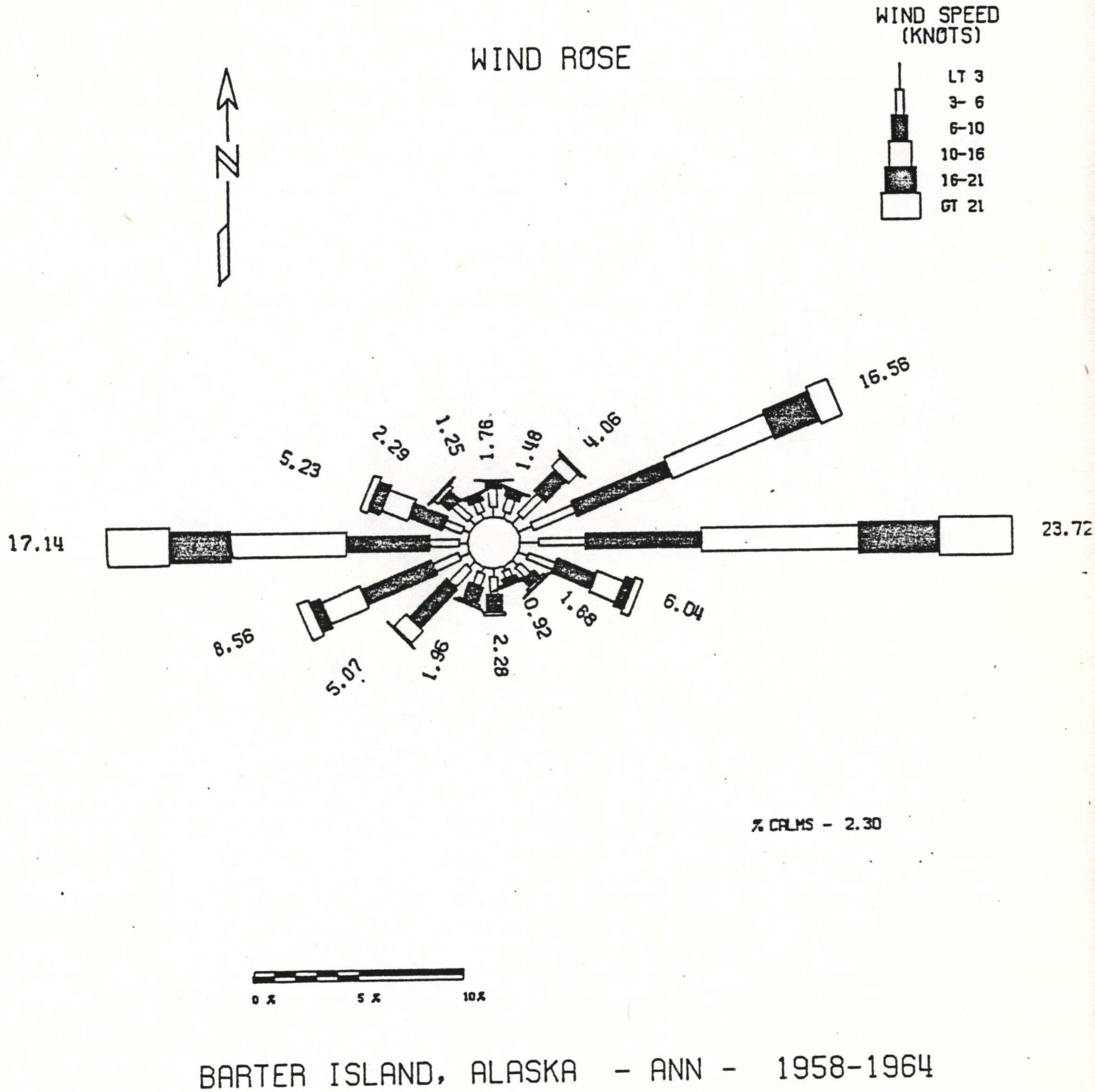
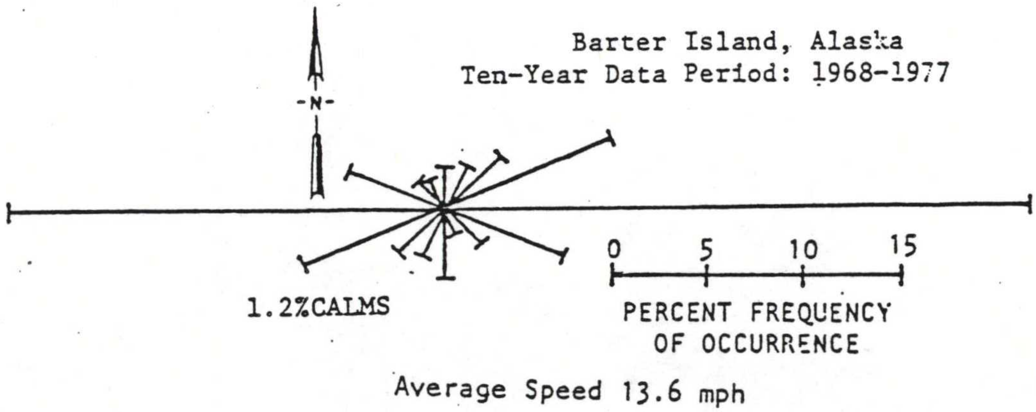

WIND ROSE
WIND SPEED (KNOTS)
LT 3
3- 6
6-10
10-16
16-21
GT 21
N
16.56
4.06
1.48
1.76
1.25
2.29
5.23
17.14
23.72
6.04
1.68
0.92
2.28
1.96
5.07
8.56
% CALMS - 2.30
0 %
5 %
10 %
BARTER ISLAND, ALASKA - ANN - 1958-1964

Figure F-2



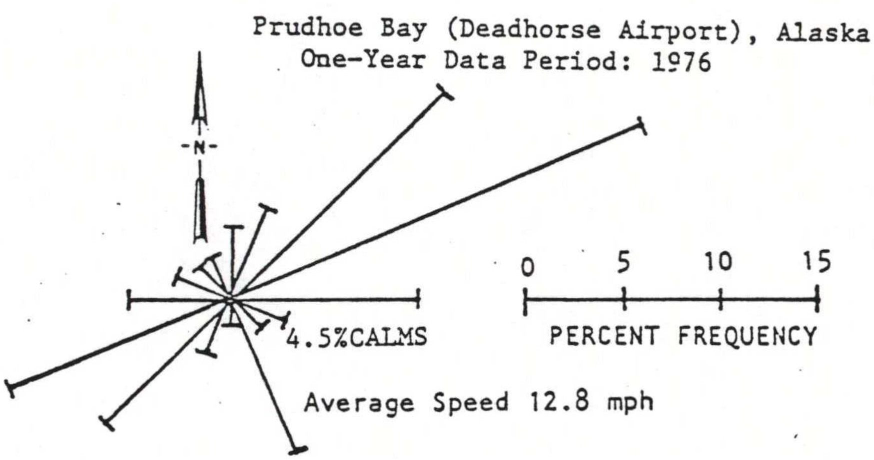


Figure F-3. Annual Wind Roses

TABLE F-1. ANNUAL FREQUENCY DISTRIBUTIONS OF PASQUILL STABILITY CLASSES WITH AVERAGE WIND SPEED BY STABILITY CLASS

		Barter Island (1968-1977)		Prudhoe Bay (1979-1980)	
Stability Class	Definition	Annual Frequency (percent)	Average Wind Speed (mph)	Annual Frequency (percent)	Average Wind Speed (mph)
A	Extremely Unstable	0.00	N/A	9.84	6.1
B	Unstable	0.86	4.7	6.28	8.4
C	Slightly Unstable	4.54	6.3	8.76	11.3
D	Neutral	79.54	13.4	62.23	14.1
E	Slightly Stable	9.36	7.9	7.08	6.7
F	Stable to Extremely Stable	5.70	3.6	5.81	3.8